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AIR FORCE JOURNAL of LOGISTICS

SPRING
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AFRP 400-1

VOL VII NO 2

SPRING 1983

Air Force Journal of Logistics

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Purpose The *Air Force Journal of Logistics* is a non-directive quarterly periodical published in accordance with AFR 5-1 to provide an open forum for presentation of research, ideas, issues, and information of concern to professional Air Force logisticians and other interested personnel. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

Distribution Distribution within the Air Force is F through the PDO system based on requirements established for AFRP 400-1 on the basis of 1 copy for every 15 logistics officers, top three NCOs, and professional level civilians assigned.

Subscription For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Back issues are not available.

Manuscripts (typed and double-spaced) should be between 2000-3500 words. References should be numbered and attached at end of manuscript. Figures (separate pages) should be numbered consecutively within the text. Tables should be prepared within the appropriate text (AUTOVON 446-4087; Commercial (205) 279-4087).

Toward State-of-the-Art Logistics

General James P. Mullins, USAF
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We live in a world today characterized by rapid, dynamic change—change which results in a great deal of uncertainty. The growth of new nations, the competition for the means of economic and social achievement, and the rapid diffusion of technology throughout our environment have often caused violent political, social, and economic realignments among nations. Our country, along with the rest of the industrialized world, is becoming more dependent on a finite supply of energy and other strategic resources.

The nature of warfare has also changed, again because of technological advances. Modern weapon systems can now provide virtually any nation with the capability to threaten or even destroy another nation. As recent events in the South Atlantic so graphically demonstrate, wars can occur at any time and any place, and can involve almost any country.

Technology today, not only requires that a nation defend its geographical integrity, but also demands it defend vital interests, including energy supplies, sources of strategic materials, and close allies. Of course, historically, the only proven way of doing this is with a strong military force, one that can fight at any moment and one that has the combat capability it needs at all times.

The key to our having this essential military capability is logistics; for, ultimately, the limiting factor on what any military force can do depends on its logistics support. It is a fact that without adequate logistics, the finest weapon systems and the most highly trained personnel will be fighting on the losing side.

How do we provide logistics support in the dynamic, uncertain environment we live in today? How do we cope with episodic procurement, uncertain funding, and unpredictable conflicts? And considering the "come-as-you-are" scenarios that now seem likely, how do we cope with the extremely long supply lines, unstable political situations, and austere environments that characterize many of our vital interest areas today?

Clearly the old way of doing things just will not work. We cannot rely on such traditional feedback systems as military exercises to tell us what we should be doing, to identify what questions we ought to be asking, or to help us direct resources where they are most needed. We no longer have that much time, and we no longer can spend months planning and conducting an exercise, and then writing up and evaluating what we have been doing. The entire war in the Falkland Islands required less time in execution than most exercises require in planning.

I believe we can deal with the uncertainties that lie before us, but only if we have some "real-time," proactive system for prioritizing what we must do and for reducing to the irreducible minimum, all the variables with which we must deal. This means a dynamic, interactive system to tell us what we should be doing and to identify our deficiencies. That way, when the unexpected does occur or when a war does start, we will have the information we need and most of the decisions already made. In addition, those decisions we could not make beforehand will have been so structured that we will be able to make them quickly when and if the time comes.

Ultimately, whatever system we do develop must, not only be totally interactive and dynamic, constantly distinguishing fact-of-life changes anywhere in the environment, but also it must employ some automatic mechanism to take corrective action in order to respond to those changes.

What I have in mind is not unlike many of the automatic, negative-feedback systems that are ubiquitous features of our everyday lives. In fact, I envision this management system as operating like a heating thermostat in the home. In winter, when the temperature in your home starts dropping, the thermostat senses this fact-of-life change and causes corrective action to be taken—it turns *on* the furnace. Then, when the house warms up, the thermostat senses this environmental change and automatically takes another corrective action—it turns *off* the furnace.

The thermostat, of course, is a relatively simple automatic system; but there are many very complex systems, ones we rely on daily for life itself. Consider how the thyroid gland automatically regulates metabolism and growth in the human body or how the pituitary gland, in turn, automatically regulates thyroid activity.

Basically, the thyroid gland monitors food intake by measuring the amount of iodine we eat. It then produces an appropriate amount of the hormone thyroxin, which controls metabolism and other bodily functions. The thyroxin, in turn, is monitored by the pituitary gland, which acts as the control mechanism. It produces the hormone TSH, based on the thyroxin it senses, and ultimately controls the thyroid gland's activity and, thus, the body's metabolism.

The point here is that thermostats or thyroids are totally automatic management systems—systems whose function it is to ensure a home stays warm or that a person continues to live. To accomplish these functions, they monitor the environment, determine if action must be taken, and, in fact, cause that action to be taken. In a home or in the human body, such systems are necessary and natural, because no other way can cope as well with the multitude of environmental variables. Imagine what would be involved in trying to manually control the temperature in your home or the metabolism in your body.

Now given the realities of the world today, the vulnerabilities our nation has, and the threats we are likely to face, "manually controlling" logistical support for the Air Force makes even less sense than manually controlling the temperature in your home or the metabolism in your body. Automatic systems can do the job far more reliably.

That is why we need such a system, one integral to our daily operations—a management system which is part of our normal routine, which constantly tests for things out of sync, and which takes corrective action almost immediately.

What I am describing here would have been improbable a few years ago. The technology to monitor all the variables and

ask all the questions did not really exist in usable and available form until recently. But it is here today. Modern data processing and computing capabilities, coupled with the development of artificial intelligence, will now let us develop and use such a management system. They will let us automate much of our data collection, evaluation, and action formulation; and they will allow us to function proactively, in real time, with the uncertainties we face.

The first thing we have to do to build such a management system is know where we should be going and what we have to do to get there. That is where combat capability and meaningful measures of merit enter the picture. Combat capability is where we are going and meaningful measures is the system we are going to use to indicate our progress.

Of course, being able to fight wars is the reason the military exists in the first place; and, consequently, it is the real mission of the Air Force Logistics Command (AFLC). That is why everything we do, and every action we take should, in some meaningful way, contribute to the combat capability of the United States Air Force.

Once we identify what we should be doing, we can prioritize our activities in terms of how much combat capability each provides. For example, we can look at what weapon systems we support and what functions we perform for each of these systems. We can then assign relative priorities to each function, product, and process according to the relative priority of the respective weapon system and its associated tasking.

All this will provide us the basis for making rational decisions regarding what we are doing; i.e., how we are going to allocate the resources we do have to obtain the greatest possible combat capability. Let us consider our support for the E–3A AWACS. That system, of course, is composed of many subsystems and parts, including everything from a windshield, to engines, to numerous black boxes. Given the combat role of this system—a role that at this time only the E–3A can perform—a relatively high priority can be established for the system itself. Also, the relative importance of each of its subsystems in terms of its executing the task can also be calculated. For example, since the airplane cannot function without a windshield, that component must have one of the highest priorities.

Ultimately, then, we can design a management system which will monitor all our weapons, giving a high priority to the most critical ones. Furthermore, this same management system can then look at the various components of each aircraft, assigning relative values of importance to each component in terms of the aircraft's performance in its wartime mission. Finally, our management system could suggest or even execute actions automatically—issue requisitions, transfer assets, or take other actions based on this prioritized model.

This, then, is where meaningful measures of merit (M^3) is heading. Today, it is simply a resource allocation system, one that enables us to quantify and prioritize what we do. But it also lays the groundwork for an automatic control system tomorrow. Since M^3 provides a precise, quantifiable model of what we do, prioritized according to combat capability, it also furnishes something that a computer can use to make decisions and take actions for us.

What we are really discussing here is a multidimensional model, one that reconciles and prioritizes according to war plan tasking, weapon system type, and the relative importance of the item or maintenance procedure required. The bottom line of all this is a model that can be continuously updated, reflecting our combat capability as it really is at any moment and causing corrective actions to be taken.

Meaningful measures of merit, then, is the first step on the road to effective logistics in a modern environment. In fact, M^3 is already producing results. We are now finding the causes for much of the logistics problems simply as a result of the improved visibility that deficiencies are receiving.

For example, Figure 1 shows an M^3 vectorgram representing simulated AFLC support to the other operational commands. Commands within the inner circle are receiving good support, those in the middle area have some problems, and those in the outer areas are showing severe problems. Note that in this simulation, Command "D" is indicating severe problems.

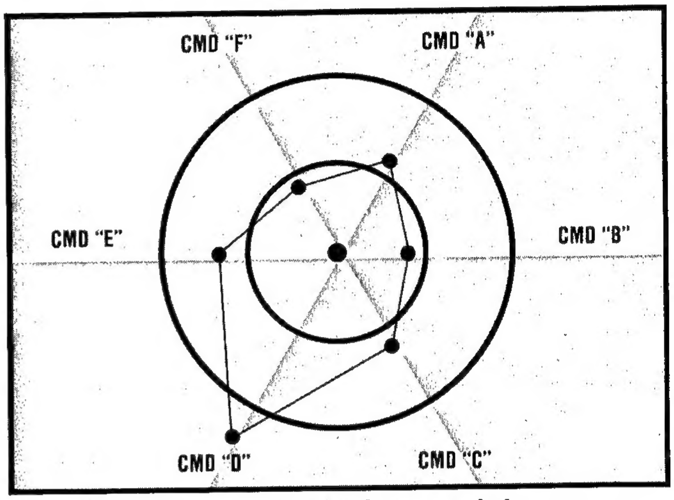

Figure 1: Support Commands (simulated vectorgraph shows support to Command "D" is clearly out of limits).

Figure 2 shows specifically what our support status is for Command "D." In this simulation, weapon system "C" support is clearly in trouble. This, of course, might well be a very high priority concern, since much of our combat capability could depend on this system.

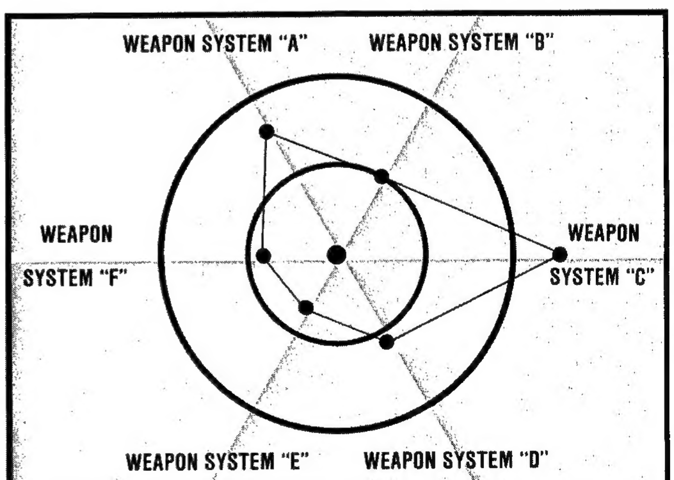

Figure 2: Support to Command "D" (simulated vectorgraph shows Weapon System "C" as the major problem area).

Dropping down yet another indenture in Figure 3, we can pinpoint exactly where the problem areas are: engines and

exchangeables. Figure 4 looks at exchangeables and shows that the problems primarily relate to planning, programming, and budgeting, and to the lack of adequate funding. Such problems, of course, require Air Staff attention; this, then, indicates that we in AFLC should consider some type of joint AFLC/Command "D" advocacy in the Air Staff to redress them. The M^3 system gives us the visibility to do this by relating to the Air Force mission these specific exchangeables problems.

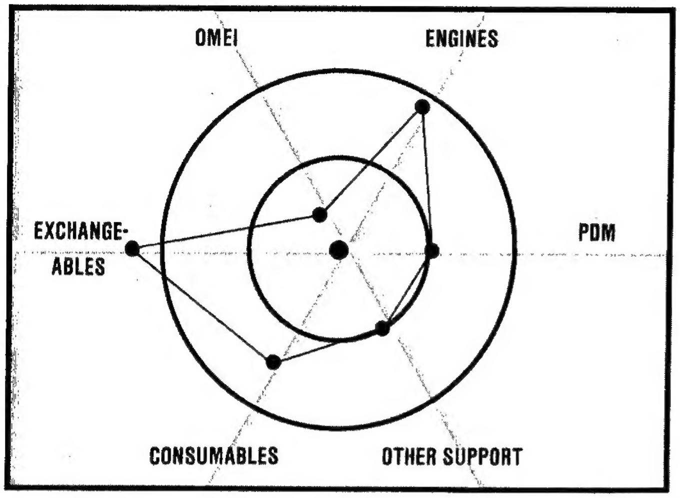

Figure 3: System "C" Support (simulated vectorgraph shows exchangeables and engines as being the major problem areas for the system).

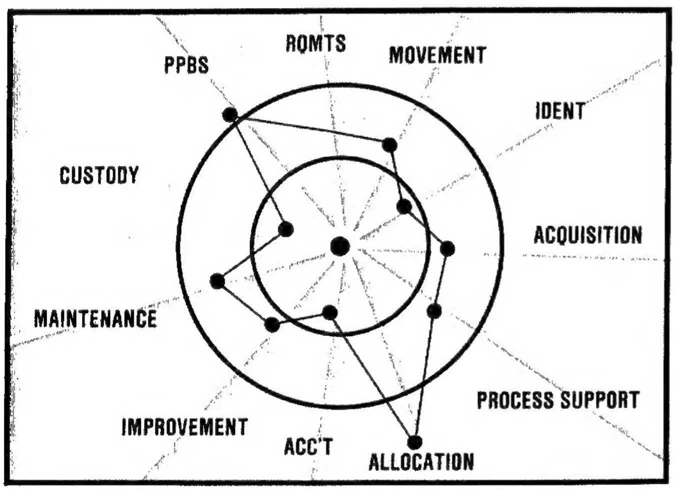

Figure 4: Exchangeables (simulated vectorgraph shows problem areas for exchangeables).

Of course, the M^3 system can also provide a means of managing internal resources to redress specific problems. For example, besides the exchangeables problem, Figure 3 also indicates that serious deficiencies exist with engines. The Figure 5 simulation, in turn, shows that stock levels are inadequate; i.e., we do not have enough spare engines on hand.

To find out why, we drop yet another indenture in our internal M^3 system, as shown in Figure 6. In this hypothetical example, the specific problem areas are quite visible: we are not processing engines quickly enough through the depot. Now this would be a problem we could do something about by simply shifting what resources we already have in AFLC. We could pull manpower and other resources off lower priority systems and redirect them to the deficient system's engine lines.

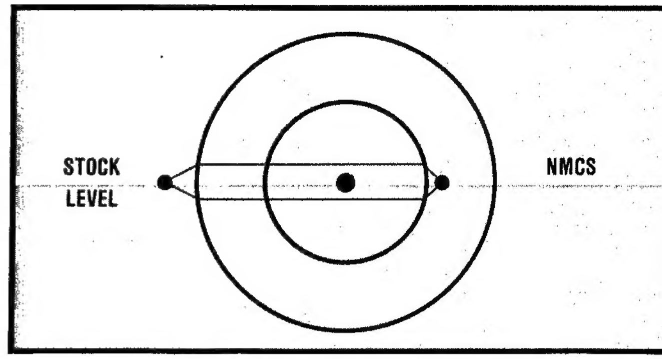

Figure 5: Engines (simulated vectorgraph shows problem area is stock level)

Such actions, of course, seem obvious, but not until we relate precisely what we do in the depot to the overall mission of the Air Force. And that is the whole point. From the M^3 system, we will know how depot flow-time affects engines, how engines affect the weapon system, how the weapon system affects Command "D's" mission, and the priority that the mission must have if this country is to execute any of its war plans. Consequently, we will have a management system which tells us how to best allocate our resources.

Here, of course, we have looked only at a single dimension of the M^3 model in related indentures; and we have done so only to show the increased visibility M^3 provides. Eventually, the M^3 model will do much more than merely provide problem visibility. In fact, it will consider many other dimensions, including priority of tasked organization, individual weapon systems, item components for each system, etc. It will be a multidimensional model, one which scales each aspect of our job against other aspects and which prioritizes according to combat capability.

We are still developing the model in the area of relating what we do to combat capability. Also, we still must come up with a "game plan" to correct the deficiencies we have identified, either by reallocation of internal resources or by external advocacy in the Air Staff and other major commands. But we have made substantial progress toward achieving state-of-the-art logistics.

The bottom line of all this is that AFLC's goals and objectives are now being derived from the war plans, weapon systems, and tasked agencies—the ingredients that give the Air Force its combat capability and help provide this country the defense it must have for the future.

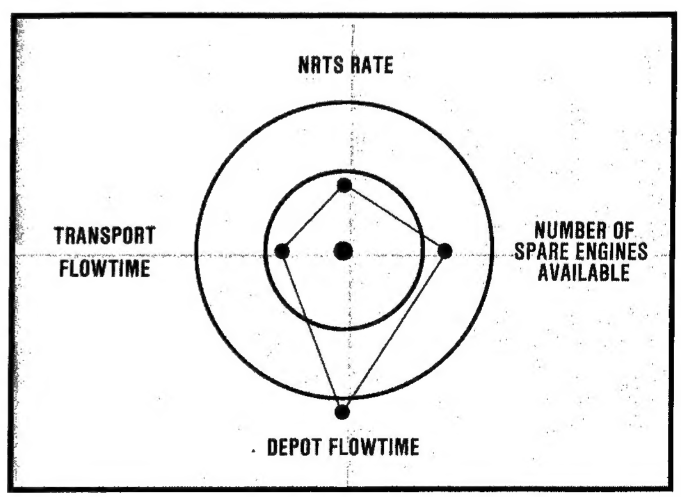

Figure 6: Stock Level (simulated vectorgraph shows depot flow-time as the major problem).

USAF LOGISTICS POLICY INSIGHT

PPAC Established at Wright-Patterson

The Air Force Systems Command and Air Force Logistics Command have established a joint Product Performance Agreement Center (PPAC) at Wright-Patterson AFB, Ohio. The purpose of this center is to foster an improved use of contractual product performance agreements by Air Force acquisition activities. The objective of these contractual arrangements is to improve the inherent availability of Air Force weapon systems. PPAC functions are (1) to determine the effectiveness of existing product performance agreements, (2) to improve future appreciation of these agreements, (3) to serve as a centralized agreement data bank, and (4) to provide technical support to Air Force acquisition activities in selecting, contracting, and administering these agreements.

Airlift Requirements Adjusted

The Office of the Secretary of Defense (OSD) has directed a reduction in the heavy demand for airlift during the early stages of military contingencies. USAF has developed a Logistics Readiness Initiative to meet this tasking, the NATO Prepositioning Procurement Program (PPP). HQ USAF, working with USAFE, the deploying commands, and AFLC, is identifying assets for in-theater prepositioning which will reduce airlift requirements to Europe during contingencies. When completed, this initiative will provide significant airlift savings. The Supply Policy and Energy Management Division is the OPR for the PPP.

Future Direction of Supply System Discussed

A panel of supply personnel, chaired by HQ USAF/LEYS, convened at the Pentagon, 7-11 June 1982, to address the future direction of the Air Force supply system. The objective of this meeting was to develop a concept of operation to focus on the development of the Air Force supply system in the post-Phase IV environment. The resultant document, the *White Paper on Future of Air Force Supply*, will serve as a guide in future supply planning and development efforts. It is intended to be a "living" document subject to revisions. Copies of the White Paper have been sent to all major command DCS/Logistics and Directorates of Supply. For additional copies, send request to HQ USAF/LEYS, ATTN: Lt Col Lombardi.

Contracted Service Evaluation Needed

As various services are contracted out, we depend more and more on contractor performance of vital base services. An important part of assuring that contractors provide acceptable service is the assignment of qualified quality assurance evaluators (QAEs) pursuant to AFR 70-9. The commands have been waiving the AFR 70-9 qualifications requirement in many instances. While this may be necessary in limited cases, we must take action to assure that qualified personnel are made available to perform these important functions.

TDY Fuel Authorized

AFM 67-1, *USAF Supply Manual*, has been revised to permit individuals in a TDY status who are authorized on orders to rent or lease a vehicle (not contracted through base contracting offices) to obtain government fuel from USAF base service stations. The travelers must present a copy of the TDY orders authorizing vehicle rental and a copy of the lease or rental agreement at the time fuel service is requested. One copy of the fuel issue document must be filed with the travel voucher to show that government fuel was utilized. The Energy Management Office of the Air Staff is OPR for this newly authorized policy.

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Air Force Logistics Strategy for the 1990s

Colonel Harry L. Gregory, Jr., USAF
Director of Plans and Programs
Hq Ogden ALC (AFLC)
Hill AFB, Utah 84056

"If there is one characteristic of modern Soviet warfare that has been particularly manifested on their battle fields, and which is probably emphasized more than anything else in current Soviet doctrine, it is surprise. It is my opinion that the Soviets—in the foreseeable future—will not attack in Europe without surprise and my opinion that they can achieve surprise. . . . I believe that under the existing circumstances, a Warsaw Pact surprise attack will be successful, and that we will lose a war in Europe."

Colonel Trevor N. Dupuy
in *The Evolution of Weapons and Warfare*

Introduction

The modern art of war is composed of three coequal, interdependent elements—strategy, tactics, and logistics. Proficiency within *each* element and comprehensive integration of *all* elements are prerequisite to success on the battlefield. The evolution of technology in warfare has settled any question of the criticality of logistics—an effective fighting force is contingent on those forces which the logistics community can make available for combat and then sustain through the requisite period of conflict. It follows that wartime decision making must include active consideration of strategy, tactics, and logistics.

Unfortunately, far too many commanders are of the persuasion that wars can be won by executing strategic and tactical operational plans, dismissing logistics considerations by assuming ready availability of the assets needed to accomplish the task. Logisticians, for their part, have tacitly accepted a secondary role in the decisions of warfare by remaining bogged down in the quagmire of detailed management of the myriad facets of logistics.

Logistics is often perceived as an unexciting aspect of war, inferior to strategy and tactics despite the fact that "logistics makes up as much as nine-tenths of the business of war."[1] Indeed, American success in waging war, as demonstrated in World War I, World War II, Korea, and Vietnam, has been in large part based on a flexible and responsive logistics system.

Logistics support concepts must judiciously take into account the consequential aspects of its operative environment, identifying points of likeness and emphasizing points of difference between past and future. Inherent in any viable concept is the flexibility to adapt to pertinent changes in the environment. Unfortunately, the USAF is clinging to a bankrupt, World War II vintage logistics strategy: we have failed to fully consider the implications of logistics on war, or adapt strategy to fit logistical capabilities.

". . . the friction within any machine—human or mechanical—increases in proportion to the number of its parts—a prime example of the law of diminishing returns. . . the speed and range of successive new means of transportation have been largely, if not completely, offset by the enormous increase in friction and, above all, by the quantities of supplies required."

Martin Van Creveld in
Supplying War

Current Logistics Concepts

A Strategic Psychosis*

In the 1967 Middle East war, the Israelis took the Arab Air Forces out of action at the beginning of the war by attacking them on ground and destroying most of their aircraft. This in turn happened to us at Pearl Harbor and in the Philippines during World War II, while Hitler attempted to destroy the RAF by bombing their bases. Inexplicably, this principle of war has been essentially forgotten because U.S. forces operated with an almost inconsequential threat of attack against our air bases through most of World War II, Korea, and Vietnam.

Yet we are now confronted by a numerically superior enemy whose doctrine places foremost emphasis on surprise. He possesses airborne forces capable of seizing our forward aerial ports and armored and artillery forces whose anticipated rates of advance will place our forward air bases under heavy fire in the very early hours of attack. Most foreboding here, however, is that recent enhancements in Soviet tactical aviation (and especially development of long-range strike capability) make USAF overseas bases prime targets for preemptive strikes.

The Achilles Heel

Since World War II, the U.S. Air Force has operated from major fixed installations around the world and particularly in Europe. This traditional forward basing concept has continued with only nominal adjustments to the more technologically capable and increasingly lethal Soviet threat. An extensive aircraft hardened shelter program and increased complexity of

*A psychosis is a mental aberration characterized by lost contact with reality.

support requirements have combined to underline the vulnerability of vital logistics resources as our Achilles heel. Damage to either an avionics intermediate shop (AIS), war reserve materiel (WRM) asset storage site, petroleum, oil and lubricants (POL) facility, munitions storage area, vehicle park, or other key logistics resource could bring flying operations to a halt. The point is that with the advent of hardened aircraft shelters, the most lucrative and vulnerable air base targets are airfield runways and logistics support resources.

While survivability, mobility, and flexibility are premium characteristics of logistics support key to success in future war, we have doggedly maintained our forward basing policy (the A-10 is the sole exception). Even though the technology of war has been revolutionized and Soviet capabilities substantially increased, such policy has led to entrenchment of traditional support concepts despite compelling logic to the contrary. As a consequence, *more complex support requirements have been introduced adding to the inflexibility and vulnerability of an already corpulent logistics tail.* Repair of aircraft avionics components offers a graphic illustration:

> The advent of new microprocessor technology has provided a capability to incorporate Built-in-Test (BIT) into avionics systems to provide on-aircraft condition monitoring, failure detection, and fault isolation. Ideally, reduction of costly intermediate level support equipment and quantities of expensive spares should result. However, BIT itself: increases component complexity and cost, requires its own software support capability, and needs support equipment to verify that an indicated fault is in the hardware, not in the BIT per se.
>
> For the F-15 and F-16, this support equipment is known as the avionics intermediate shop. The F-15 AIS requires dedicated external power generators, a temperature controlled environment, and 3.6 C-141A load equivalents (plus personnel) for airlift. The AIS can check out only one of the F-15's 45 LRUs at a time. It takes 30 minutes to connect an LRU to the AIS and an average of 3 hours to process a single LRU. The readiness of the F-15 is critically dependent on the readiness of the AIS itself which in turn is dependent on highly skilled personnel for operation and maintenance. In addition to introducing critical resources into a vulnerable combat environment, we have limited our capability to support high surge combat operations by introducing the AIS bottleneck.

The costs, complexity, and reliability of USAF logistics support are also exacerbated by the great diversity of equipment in the inventory. The great numbers of *unique* items require *unique* technical skills and training, increased numbers of facilities, different inspection and test concepts, separate materiel distribution approaches, etc. This means that people and materiel are not used in a timely and economic manner. While acknowledging unique operational needs for some missions, it is unconscionable that each aircraft have unique communications, radars, fire control, etc., or that every subsystem in the inventory have unique test equipment. Increased standardization offers proven economics and could pay handsome dividends in enhancement of USAF war-fighting capabilities.

Additionally, failure to cull logistics support requirements to the essential bone and muscle impairs our capability to effectively manage combat essential requirements. Critical logistics resources deployed at forward USAF bases present a lucrative, target-rich objective for the enemy. Minimizing logistics resources at forward bases to only those that contribute directly to the combat mission would reduce vulnerability and at the same time enhance war-fighting capability.

Obstacles to Supportability

Increasingly complex, duplicative, and more expansive support requirements are borne in the acquisition process. Many worthwhile initiatives have focused attention on reducing life cycle costs; however, many are based on cost-effective analyses of a scenario detailed to the degree that flexibility of the force to meet any unexpected contingency becomes questionable. Fielding of the AIS was certainly not supported by a realistic, well thought-out scenario providing for response to a wide range of combat activities, but sold on peacetime economies. Acquisition support analyses should be based on realistic wartime support concepts and initiatives to reduce costs judiciously applied to avoid suboptimization.

Because of skyrocketing costs, extended production lead times, and increased complexity, modern weapon systems will be retained in the inventory for increasingly longer periods than was experienced in the past—some B-52 aircraft are now older than the pilots who fly them. Modifications of these weapon systems will be necessary to: (1) provide enhanced operational capabilities to counter more sophisticated enemy threats, (2) ensure safe operation through the extended life span by replacement of worn-out components, and (3) improve the reliability of installed systems.

Unfortunately, the acquisition process has failed to acknowledge this reality. Current acquisition practice typically fields "fringe technology" packaged in a system optimized for performance. During engineering design there are little, if any, trade-offs between performance and reliability and seldom are provisions made for future modifications of the weapon system. Inevitably, reliability proves to be far less than forecasted and corrective actions in the form of costly, complex, and disruptive modifications follow.

Air Force logistics support should be organized for war and be able to support peacetime operations from within that framework. With the exception of a few externally imposed and ill-advised attempts to achieve peacetime economies at the expense of war-fighting capability, the USAF logistics structure is well postured to transition from peace to war, limited primarily by resource constraints. To support the high sortie rates in the quick turn environment of the modern battlefield, dramatically increased consumption of POL, munitions, and spares will be required. Availability of these resources critically limits Air Force readiness and sustainability. Requirements for these commodities are based on providing sufficient on-hand stocks to meet initial wartime demand until resupply becomes available from the industrial base.

From 1976 to 1981, the planning assumption for the length of the war scenario (the procurement objective for these war consumables) was reduced from 180 to only 60 days to accommodate other funding priorities (vis-a-vis force modernization). Although such procurement objectives are always achieved in the "out year" budget program, current year support funding has perennially fallen far short, jeopardizing force readiness and sustainability. For example: "Some U.S. tactical air forces have less than 14 days' supply of munitions. Some squadrons don't even have the basic combat loads for an initial sortie."[2] "The Air Force has told Congress that none of the Air Force weapon systems has the capability to fight for a full thirty days with the present stockpile of spares."[3] Up to 50% of the fighting aircraft are not mission capable.[4]

Concurrent with the reduction of war reserve materiel stocks, increasing weapons complexity has combined with shortages of critical raw materials, tooling and forgings, and trained personnel to increase production lead times to an average of two years. For example, landing gears require 15-35 months; radars, 20-30 months; and engines 15-30 months.[5] So, simultaneously with reduction of available asset levels to less than 30 days, lead times for production of resupply assets have increased alarmingly.

Although the Air Force has recently programmed significant enhancements of WRM stocks, subsequent budget cuts have emasculated expected gains in combat capability; the extended lead times characteristic of today's complex weapon systems mean the industrial base will not be able to provide resupply when initial stocks are exhausted. The result is that we must fight a come-as-you-are war in which we cannot sustain the battle for very long.

Corporate Planning

Air Force resource allocation decisions are made by the Air Force Board Structure. In this adversarial process, individual logistics programs compete for available funding with those for research and development, system acquisition, personnel, etc. The problem inherent in this process is that resources are not systematically allocated to achieve broad corporate goals. To illustrate, suppose the USAF wants to procure a squadron of F-16 aircraft. Procurement of the aircraft and initial spares would be a single decision; the peacetime replenishment spares, war readiness spares kit (WRSK) spares, other war reserve materiel (OWRM) spares, munitions, support equipment, simulator, vehicles, calibration/test equipment, depot maintenance, etc. (needed to adequately support that F-16 squadron) would each be separate decisions. Each is grouped in commodity groups with requirements for other weapon systems; e.g., F-16 WRSK spares are included with other system requirements in a single decision line for all WRSK spares. This arrangement does not facilitate decisions that lead to a balanced combat capability. For example, procurement of an F-16 squadron could be funded by cutting the replenishment spares program even though the spares are necessary to achieve a fully capable system. The logistics community, then, is forced to prioritize the funding shortfall among competing weapon systems with inevitable degradation in readiness and sustainability.

In addition, bombs, bullets, spares, and fuel are low visibility items. Even though significant MAJCOM support for readiness has been evident in the last year, logistics support programs have relatively less constituency than the more glamorous research and development (R&D) and acquisition programs. Consequently, support programs are often used as slush accounts dipped into to finance "higher priority" procurements with the inevitable degradation of readiness and sustainability.

The Problem

It is readily apparent that the USAF lacks a viable logistics strategy to meet the future. Instead of a single integrated and integrating set of ideas, beliefs, and concepts, we have had a complex and sometimes contradictory mélange of notions, principles, and policies. Little changed since World War II, our current support concept has failed to adapt to environmental dynamics. The evolution of technology on the modern battlefield has confronted strategy with the realities of finite resources; at least one logistics factor will always impose limits on a military force. The challenge is to get the most war-fighting capability possible from available resources—and that is what logistics is all about. To reconcile current logistics philosophy with resource reality, the status quo must be challenged. Tradition, old ways of doing business, established mind-sets, standard operating procedures—all must be scrutinized.

Although numerous successful initiatives have been implemented to improve supportability, these techniques for "doing more with less" have treated symptoms, but not the disease. Less and less effective in a limited resource climate, traditional support philosophy has endured as a given, oblivious to all challenges, even though the resulting current support posture is marginal at best. A new framework for logistics support—a logistics strategy—is needed to ensure full realization of war-fighting potential from available resources.

Logistics Strategy: A Definition

Logistics can be viewed in three complementary generic levels: logistics programming, acquisition logistics, and operational logistics. First, the allocation of resources to meet logistics requirements, "logistics programming," is a function of logistics integration with national strategy and the economy. It is determined by the defense decision-making process (service executive level/DOD Planning, Programming, and Budgeting System/OMB/Congress). "Acquisition logistics" is the application of logistics resources to influence weapon system design for supportability and to create a support capability. Third, "operational logistics" is the employment of logistics resources to support the operations of combat forces. (In this context, operational logistics includes the traditional logistics functions of maintenance, supply, transportation, and procurement at depot, intermediate, and organic levels). Simply, logistics programming provides the dollars, acquisition logistics ensures development of supportable weapon systems, and operational logistics is the direct application of resources to support unit operations in the field.

Analyses of these definitional views of "logistics" belie a schism between categories of logistics that is painfully evident in current practice. Examples abound of disconnects and suboptimization of one level at the expense of the whole. There is a critical need for a thread of consistency to weave coherence through all levels and to provide the underpinning for a more active leadership role for logisticians. I define that thread as "Logistics Strategy."

"Logistics Strategy" is the theory of support that determines the allocation of resources to logistics requirements and employment of those logistics resources to sustain war-fighting capability. Logistics strategy is that thread of consistency that ensures logistics programming, acquisition logistics, and operational logistics are bound together in a coherent support concept to maximize war-fighting capability.

In addition, it is particularly critical that logistics strategy be sensitive to changes in the major factors that define its environment—the politics of competition for limited national resources that constrain logistics programming, the impact of dynamic technology which provides new capabilities and attendant logistics support challenges, and the increasingly more potent Soviet threat. Not only, then, is logistics strategy the glue that binds the three levels of logistics together, it is also the mechanism that keys appropriate responses at each

level to changes in the external environment.

Since we "...must always remember that *sustained combat effectiveness* is the proper objective of logistics,"[6] this concept of support must be firmly based on maximizing the war-fighting capability of deployed operational forces; i.e., logistics strategy must be consistent with operations strategy. Conversely, operations strategy must take into account logistics capabilities and, if necessary, be changed to effect an improved logistics posture where overall combat effectiveness is enhanced. In summary, war-fighting strategy should be developed through the interaction of operations and logistics strategies to maximize sustained combat effectiveness rather than suboptimization of one or the other at the expense of the whole. This concept of logistics strategy is presented graphically in Figure 1. Its application to the environment of the 1990s suggests new courses of action for the Air Force.

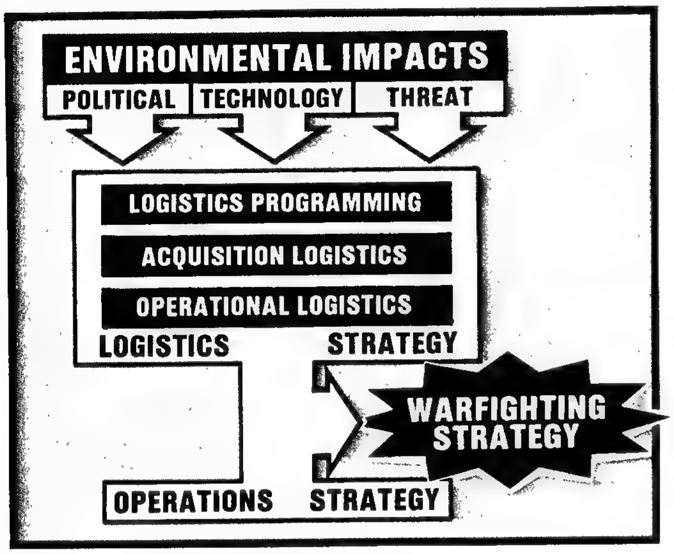

Figure 1: Concept of Logistics Strategy.

A USAF War-Fighting Strategy for the 1990s

In a future war, the USAF mission will be to defeat a numerically superior enemy on an extraordinarily lethal battlefield. Success will require massive efforts from materiel and personnel—dramatically increased sortie rates, combat quick turns, and substantially increased consumption rates of logistics resources. Existing resources and current concepts are inadequate to this challenge. Relief by additional funding is highly improbable—there will be little or no *real* growth in the USAF budget and future cuts in logistics support funding may erode earlier gains. The bottom line, then, is that strategy must be changed to ensure optimum employment of available resources.

Basing In-Depth Concept

"Strategy: Air Force war-fighting forces should be deployed in a basing in-depth concept."

A basing in-depth concept for all war scenarios (similar to the A-10 European forward basing concept) promises significant advantages. This concept is based on two generic types of air bases distinguished by operational function and distance from the forward edge of the battle area (FEBA):

> Forward fighting bases (FFBs) would be located within 250NM of the FEBA and main operating bases (MOBs) situated 250NM or more beyond the FEBA. For example, in Europe FFBs could be sited in Germany and MOBs in Great Britain and Spain/Portugal; in a hypothetical Iranian conflict, FFBs could be sited in Oman or Muscat and MOBs in Saudia Arabia or Egypt.
>
> The emphasis at FFBs would be on rapid and high combat sortie generation. Approximately 250 personnel would accomplish functions of operations, command and control, and logistics support (limited to dearm, service, refuel, load, and rearm). Aircraft would continually rotate from the MOB to stage operations from the FFBs for short periods (5-10 days) of deployment. Only on-equipment maintenance would be performed and remove-and-replace spares limited to high-use components configured in a forward operations spares kit (FOSK). Security, messing, and housing would be the only base support functions provided.
>
> Primary wing infrastructure would be located at the MOB which would provide support and service functions for four to eight FFBs. Aircraft with maintenance problems beyond the capability of an FFB would recover at the MOB or, if necessary, be repaired by a TDY maintenance team from the MOB. A logistics readiness center (LRC) at the MOB would manage logistics support requirements for the MOB and each supported FFB. Dedicated intratheater airlift and a portable supply mini-computer (similar to the European Distribution System (EDS) and the Combat Supply System (CSS), respectively) would be needed to effectively implement this approach.

A basing in-depth concept promises significant advantages: By removing concentrations of critical logistics support assets from forward bases, vulnerability is substantially ameliorated. Dispersal and extensive camouflage of logistics assets at FFBs and hardened logistics facilities at MOBs will further enhance survivability. Additionally, longer enemy egress distances would enhance air defensive efforts. Reduced vulnerability increases flexibility as surviving logistics assets can be employed to meet unforeseen contingencies; flexibility is also enhanced by the opportunity to use a "chessboard" strategy rapidly concentrating and dispersing forces at various FFBs in the increased depth of the modern battlefield. The resulting reduction in complexity of organization and equipment in forward areas decreases the potential for friction, permitting optimization of forward bases for high volume sortie generation. Integration of CONUS reinforcing units would also be facilitated by deploying arriving units at operational MOBs, or opening new MOBs, minimizing perturbations at the combat sortie producing FFBs.

Two-Level Maintenance

"Strategy: Air Force maintenance should consist of two levels of repair: on-equipment and depot."

The cost and complexity inherent in maintenance of modern weapon systems are moving us away from component repair at base level. Arguments that elimination of intermediate level maintenance and adoption of a two-level maintenance concept would be more cost-effective are well known and will not be expounded here. Instead, adoption of a two-level maintenance concept is advocated as a way to *maximize war-fighting capability* on the battlefields of the 1990s.

The increased complexity of intermediate level maintenance has imposed debilitating liabilities on the logistics support system in terms of vulnerability, flexibility, and efficiency (e.g., the critical dependence on F-15/F-16 operations on the

functioning of the AIS). These operational deficiencies could be eliminated by removal of complex, vulnerable intermediate assets from the field.

Elimination of intermediate level maintenance would exploit improvements in component reliability, place more reliance on throwaway expendables, and increase depot maintenance workload. Increased depot inspection and repair should require increased depot resources but decrease maintenance downtime. With little or no capability for component repair, combat units will become more dependent on lines of resupply. To compensate for the resulting decline in base level self-sufficiency, three steps are recommended:

(1) Additional spares should be procured for the logistics pipeline and for an extended range and depth of war reserve spares.

(2) An enhanced transportation capability would be needed for a more responsive logistics system: An intra-theater airlift system analogous to the European Distribution System is necessary to reallocate theater resources in the most effective manner.

(3) Further use of modular concepts (similar to F-100 engine) for maintenance should be designed for new systems wherever appropriate.

An added dimension of flexibility could be provided by expanding the role of AFLC's combat logistics support squadrons (CLSS). In a contingency, a CLSS beefed up with intermediate and depot support equipment, an expanded range of spares, and additional skilled technicians (sourced from ALC production functions) could be deployed to the MOB. In effect a mobile "mini-depot" for the theater, the CLSS would accomplish component repair, repair battle damaged aircraft, and perform other maintenance beyond the capability of the supported unit, complementing and enhancing the basing in-depth and two-level maintenance concepts.

Of course, it can be argued that the two-level maintenance concept denies the combat commander needed flexibility and increases dependence on vulnerable lines of supply. While these are valid concerns, they pale in comparison to the considerable advantages of the approach. Elimination of intermediate level maintenance would improve survivability and flexibility by reducing forward deployed logistics assets and enhance war-fighting capability by decreasing the potential for friction in simplifying forward logistics functions. The primary advantage, however, of eliminating intermediate level maintenance is that it will permit a reallocation of investment resources to procure a greater level of assets used directly in war (spares) and a corresponding smaller level of assets used to support war (support equipment, skilled technicians, etc.). In other words, greater combat leverage could be achieved for an equivalent logistics resources investment.

Plan To Incorporate Future Modifications

"Strategy: Systems should be designed to facilitate incorporation of future modifications."

The point suggested here is that weapon systems should be fielded employing practical, supportable, state-of-the-art technology and the modification process used to incorporate subsequent technological improvements over the mainframe life cycle. Therefore, it is recommended that weapon system designers use state-of-the-art technology to ensure supportable weapon systems, incorporate new technology through the modification process, and plan for future modifications by incorporating cableway space, access, panels, power supplies, cockpit space, etc., to facilitate installation of future modifications.

Weapon System Readiness Goals

"Strategy: Program readiness goals for each weapon system encompassing programmatic funding for logistics support elements needed to achieve those goals."

Recall the approach followed in the Air Force resource allocation process. A more corporate approach to resource management would be for the Air Force Council to approve minimum readiness and sustainability goals for weapon systems prior to initiation of the annual Program Objective Memorandum (POM) exercises. Readiness goals would be expressed in C-ratings and sustainability goals in days of combat capability for all forces, by mission, by theater, etc. Logistics support requirements to achieve these goals would then be programmatically included in the cost of each weapon system decision increment. The Air Force Board Structure could then make decisions on integral increments of capability with full appreciation of the total cost associated with that capability. For example, an F-16 squadron would include costs for procurement, peacetime replenishment spares (based on the approved flying hour program), WRSK spares, OWRM spares, munitions, support equipment, vehicles, etc. Planners could depend on all F-16 squadrons to have comparable capability in terms of materiel readiness and sustainability. Increments of increased capability in terms of readiness or sustainability could be added as enhanced funding alternatives. The chief advantage of this approach is that the logistics resources prerequisite to full realization of the war-fighting potential of a weapon system would be identified with funding for that system.

Separate Procurement Policy for Consumables and Reparables

"Strategy: Develop separate procurement policies for wartime consumable and repairable assets."

A huge gap exists between the time when available stocks will be exhausted and when the industrial base will be able to provide resupply. A pragmatic, near term approach is needed to deal with the resource gap following initial depletion of available stocks.

Weapon systems use two categories of materiel: (1) consumable items which are expended in operations (munitions, POL) and (2) repairable items which are used repeatedly in operations and, although they can fail, they can be repaired and returned to service (spares, engines).

Since consumable items are "consumed" in combat, sustained combat effectiveness is dependent on continuous supply. For example, munitions resupply is dependent upon manufacture to meet whatever consumption rates are experienced. Since the length and intensity of future conflicts are unknown and funding is inadequate to permit building of

adequate war reserve stocks, the maintenance of a relatively small war reserve stockpile backed by a warm production base is suggested. War reserve stocks of 30-45 days could meet initial wartime demands while maintenance of a munitions war production base would provide an on-line capability to meet increased wartime demands over an indefinite period.

On the other hand, no near term production investment is recommended for WRM repairable items. Since more than 85% of repairable supply requirements are satisfied by maintenance, if sufficient reparables are available to meet initial surge requirements, then sustained operations can be supported through repair lines; additionally, extended lead times characterize today's complex hardware. Therefore, it appears prudent to procure reparables in sufficient quantity to meet initial surge requirements (e.g., 60 days) and depend on the repair process to support sustained combat. In a resource limited environment, funding for reparables beyond initial surge requirements (plus peacetime assets) could be better used for other needs.

It is recommended that war production bases be maintained for critical conventional munitions components (at the expense of uneconomical production rates) and spares procurement limited to 60-day stockage level with full funding of maintenance repair requirements.

Conclusions

To meet the challenges of a dynamic world with a fiscally austere budget, the Air Force must be able to coax greater war-fighting capability from a given level of resources. The proposed strategy initiatives are basic to this objective and provide an opportunity to redirect funding from assets that contribute only indirectly to combat effectiveness to assets that contribute directly; i.e., things we need to *fight* a war.

Fundamental to this objective is a viable logistics strategy, the glue that binds the three levels of logistics together and the mechanism that keys appropriate responses at each level to changes in the environment. Interaction of logistics strategy with operations strategy is essential to developing an overall war-fighting strategy to maximize sustained combat effectiveness.

The challenges are demanding; the environment is dynamic and clouded with uncertainty. The bottom line, however, is that our future logistics strategy will either be a gravestone for our democratic way of life, or the cornerstone for USAF success over the battlefields of tomorrow.

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This article is the result of a strategic study project made at the National War College.

FROM 5

Reserve Forces Studied

The Air Force Vice Chief of Staff tasked the Deputy Chief of Staff for Plans and Operations to form a study group to examine appropriate Air Reserve Forces roles and missions for the year 2000. The study will address manpower, personnel, and training requirements, as well as equipment modernization and fiscal constraints. The Air Reserve Forces 2000 Study will build upon the recently completed Air Force 2000 Study within a total force context. Special attention will be given to ensure continuation of past successes in integrating the total force for both peace and wartime employment. The operational support chapter includes logistics, communications, engineering, medical, and others.

Technology To Aid Supportability

The Air Staff began a new initiative during preparation of the FY 84-88 Program Objective Memorandum (POM), to focus on available resources of the technology base which could improve supportability. Initially, the funding was modest; but with support from OSD, the program has developed into a full-scale effort. Dollars are applied against a range of avionics, electronics, and electronic warfare (EW) programs to increase reliability and maintainability. Additionally, two new logistics program elements will combine related weapon system and logistics system technologies into existing and emerging weapon systems and components. In short, the system has recognized the leverage which can be achieved from technology applications to long-standing and new logistics problems. Your problems can be identified through the Air Force Logistics Requirements programs, administered by the Air Force Coordinating Office for Logistics Research (AFCOLR/AV 785-3001).

PWS Developed

The Air Force continues as the DOD leader in the development of Performance Work Statements (PWSs) in support of the A-76 cost comparison program. PWSs have also been developed for base level services traditionally acquired by contract. The Air Force Services Contract Advisory Group (AFSCAG), chaired by HQ USAF/RDC and composed of Air Staff, AFMEA, and MAJCOM contracting and functional people, has been responsible for this effort. AFR 400-28, *Base Level Service Contracts,* is the basis for this PWS development and has been further expanded to provide a PWS format to help base activities develop their own PWSs.

Career and Personnel Information

Civilian Career Management

Logistics Civilian Career Enhancement Program (LCCEP)

Career broadening positions are established by the LCCEP Career Development Panel at major commands and comparable organizations in the field against centrally funded authorizations. These career broadening positions, which normally last two years, provide an excellent opportunity for competitively selected individuals to gain a broader range of experience than they would normally receive. The panel has announced its selections for 1983/84.

Ms. Carole Martinson, McClellan AFB CA, to HQ PACAF/LG
Mr. Carlos Salaz, Randolph AFB TX, to HQ PACAF/LG
Mr. Dennis Flint, HQ AFLC, to HQ USAFE/LG
Mr. Delane Doyle, Hill AFB UT, to HQ USAFE/LG
Mr. Ronald Hartnett, Los Angeles AFS CA, to HQ SAC/LG
Mr. Thomas O'Hara, McClellan AFB CA, to HQ SAC/LG
Mr. Donald Jackson, Travis AFB CA, to Hill AFB UT

LCCEP ACTIVITY
(FY83)
(1 Oct - 31 Dec 82)

	Cadre Reserved	*Career Essential*	*TOTAL*
CERTIFICATES ISSUED	28	29	57
Selections:			
Cadre	18	6	24*
Non-Cadre	6	20	26*
Promotions:			
Cadre	17	6	23*
Non-Cadre	6	19	25*
Lateral Reassignments:			
Cadre	1	0	1*
Non-Cadre	0	1	1*

*Includes actions on FY82 Issued Certificates carried into FY83.

POSITIONS FILLED	GS-12	GS/GM-13	GS/GM-14	GS/GM-15	*TOTAL*
BY GRADE	23	16	9	2	50

Source: OCPO/MPKCL, Randolph AFB TX

Military Career Management

AFLC Logistics Career Broadening Program

Each year, approximately 30 exceptional logistics officers are offered a rare opportunity to be groomed for future assignments to senior logistics management positions throughout the Air Force under the AFLC Logistics Career Broadening Program (LCBP). These officers are assigned to one of AFLC's five unique air logistics centers (ALCs) for three years under individually tailored programs.

An ALC is a large industrial complex responsible for the "broad spectrum" of logistics, which includes both wholesale logistics and the daily interplay between AFLC and the other operational commands. Each complex has an average work force of nearly 20,000 civilian (90%) and military personnel. They are highly motivated and well-skilled artisans, technicians, and professional people who are responsible for the distribution of a large portion of the Air Force resources. The ALC services all Air Force commands, Air Force Reserves, Air National Guard, and other military services.

The four major directorates which form the core of an ALC are Materiel Management, Maintenance, Contracting and Manufacturing, and Distribution. The military element of an ALC is headed by a major general and a brigadier general. The ALC is semiautonomous and is considered an intermediate headquarters within AFLC. There are senior military logisticians within each major directorate to share management responsibilities with key civilians. There are also a number of positions for logistics officers to provide a "blue suit" input to the management of resources which are key to every operational command's combat readiness.

It is important to note, however, that Logistics Command does not have the broad base of military positions to "grow its own" core of logisticians to manage their business complexes. Actually, there are fewer than 1,000 logistics officers in a command composed of over 80,000 personnel. The success of this ratio is dependent on a dynamic assignment system to infuse good officers from other major commands. The officers must bring with them the operations experience needed to help shape logistics decisions which reach to the very foundation of each combat capable organization in the Air Force. Where an officer was previously making a decision which affected a small number within a weapon system at their base, they are now involved with decisions which affect the entire weapon system and its combat capability.

About 1973, Colonel Steve Chag (Retired) recognized that the current personnel system was not preparing logisticians for senior logistics management positions within AFLC. A logistics officer would spend one or two tours within AFLC during his early career and would normally be confined to the ALC directorate of his logistics specialty. Colonel Chag then developed a test program at Hill AFB to rotate officers through each of the four major ALC directorates. Unlike normal "training" programs, the LCBP allows officers to actually participate and contribute, while gaining multifaceted experience which includes all levels and AFSCs of the

logistics career field. Hill's experience was so well received that Colonel Chag presented the concept to HQ AFLC and Air Staff who actively promoted the program. Together, they developed the format and objective of today's Logistics Career Broadening Program.

Those objectives have remained consistent. The focus is to provide a select group of young logisticians an early opportunity to experience the broad spectrum of logistics and to prepare them for senior logistics management positions within AFLC, the Air Staff, DOD agencies, and other operational commands. Additionally, several Communications-Electronics officer positions are included to support such specialized communications programs as satellite communications and AWACS.

Guidelines for selection into the LCBP are set by a HQ USAF Program Guidance Committee. To be selected, an officer must be a captain or a major with a record of proven ability and exceptional potential. Emphasis is on officers who have "hands on" logistics experience and are fully qualified in their current AFSC. They must have already completed the appropriate PME and civilian education for their grade. HQ AFMPC Palace Log conducts the initial screening and forwards nominations to AFLC.

There are many attractions for officers who volunteer for the LCBP. The assignment is a three-year controlled tour. "Career broadeners" receive a staff level AFSC upon entry into the program and a special experience identifier (SEI) upon completion. They also receive senior officer indorsements on OERs and have a nearly 100% promotion selection rate to major and lieutenant colonel. Follow-on assignments are excellent: squadron commander positions, intermediate/senior service school, Air Staff and MAJCOM positions, and numerous branch and division chief assignments in a variety of CONUS and overseas locations.

As the AFLC Logistics Career Broadening Program nears completion of the seventh year, it shows every sign of continued success and effectiveness in meeting its objectives.

Item of Interest

(from the Congressional Record - 20 August 1982)

"Among the many items in the conference report is a section which will put a stop to the consolidation of critical supply and logistics functions away from the armed services. This may not seem like an important issue to Members who are not familiar with it. To those of us who have studied the problem and have worked to maintain the ability of the services to control supplies necessary to do their job, it is an issue with far-reaching implications.

The gravity of these consolidations was also apparent to Mr. Aristides Sarris, one of the finest civil servants it has ever been our privilege to know. We would like to dedicate our successful efforts of the last year on this issue to Art Sarris.

Whenever I hear anyone denigrating Federal civil service employees, I need only think of Art Sarris to appreciate how wrong the critics can be. Our country was never served by a more talented and dedicated individual.

For more than 30 years, he worked in the logistics field for the Air Force. He was in the best position of anyone to witness the steady accretion of power to a central agency which was strangling the Air Force's ability to perform its mission and which was increasingly wasting taxpayers' money. It appalled and outraged him. And rage was not a common emotion to this quiet, gentle man.

Consolidation of supply and logistics is such an apparently esoteric and mundane issue that Art Sarris found it difficult to get an audience. In 1980, he was given a $10,000 award for his work in the Senior Executive Service. In 1981, he offered to return the entire award to demonstrate the depth of his concern, just to be able to get some sort of airing of the issue in a fair and open forum. His dedication was also evidenced by his constant refusal to take the retirement that he became eligible for several years ago.

Finally in March of this year, the Armed Services Subcommittee on Readiness, led by our very distinguished friend from Virginia, DAN DANIEL, held 2 days of hearings on the consolidation of management of consumable repair parts. Art Sarris sat eagerly through those hearings and was called to testify and made his unique contribution to the public record. The issue was being exposed to the light of day; and from the merits, the conclusions were inevitable.

On June 19, Art Sarris suffered a fatal heart attack. The disappointment was acute in each of us, because this is a day we all wanted to share with him."

by the Honorable Robert T. Matsui,
California

Most Significant Article Award

The Editorial Advisory Board has selected "Corrosion: A Formidable Air Force Enemy" by Major Larry G. McCourry, USAF, as the most significant article in the Winter 1983 issue of the *Air Force Journal of Logistics*.

Dyna-METRIC: An Overview

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Abstract

Dyna-METRIC is one of the latest in a series of models to help improve the management of Air Force multi-echelon, multi-indenture repairable items. The model was developed by the Rand Corporation and has recently been installed on several Air Force computer systems. This paper outlines the major features of the Dyna-METRIC model and discusses the similarities and differences of the Dyna-METRIC and MOD-METRIC models.

Background

Beginning with the pioneering work of Feeney and Sherbrooke (1966), substantial progress has been made in developing optimization procedures for stationary, multi-echelon, multi-indenture inventory/repair systems which utilize (s-1, s) inventory policies. In 1968, Sherbrooke developed the Multi-Echelon Technique for Recoverable Item Control (METRIC). The METRIC model provides a mechanism for computing optimal depot and base stock levels to minimize the total system base back orders subject to a budget constraint. This model has provided the conceptual foundation for several recoverable item requirements computations currently in use by the U. S. Air Force. In 1973, Muckstadt developed the MOD-METRIC model which extends the METRIC technique to permit consideration of multi-indentured systems. Finally, in 1976, Muckstadt developed the Consolidated Support Model (CSM). CSM extends the METRIC-type analysis to consideration of a three echelon supply system consisting of a depot as well as intermediate and base repair facilities.

Transient Models

The steady state models discussed above all use a result first observed by Palm (1938). Specifically, assume that demands arrive according to a Poisson process with rate R and service times have an arbitrary distribution with mean T which is independent of the demand process. In this case, Palm showed that for the steady state, the number of units in the system at a random point in time has a Poisson distribution with mean RT. Palm provided a similar result for the lost sales case in which demands stop when there is a stockout, while Feeney and Sherbrooke (1966) extended these results for the case of the compound Poisson arrival process. These results apply to stationary, steady state behavior. Similar results may be obtained for non-stationary Poisson processes as long as the infinite server and demand-independent service time assumptions are retained. For example, Gilbert and Faucett (1972) developed non-steady state solutions for the distribution of aircraft parts in the base repair/resupply system under the assumptions of both Poisson and compound Poisson part failures, while Demmy (1978) provided sample transient solutions for simple Poisson failure processes in a two echelon supply system. More recently, Hillestad and Carrillo (1980) also derived transient results and then utilized these equations to develop many time dependent measures of system performance. These equations have provided the foundation for the development of the Dyna-METRIC model. Before discussing specific details of Dyna-METRIC, let us consider the specific logistics system modeled by Dyna-METRIC.

The Operating Environment

Dyna-METRIC considers a three echelon inventory/repair system such as that shown in Figure 1; however, the extent to which the depot is modeled is limited. Major components in this system consist of a depot, possibly several Centralized Intermediate Repair Facilities (CIRFs), and a number of operating bases (OBs). In the current Air Force logistics system as in Dyna-METRIC, each operating base is capable of performing only limited types of maintenance, usually restricted to simple remove and replace operations at the flight line. In some instances, such as within PACAF, some of the repair facilities have been centralized to provide some specialized repair available through economies of scale. The Dyna-METRIC model enables the user to employ a CIRF concept, if desired, or to operate strictly through the base-depot relationship now used within most MAJCOMs. Parts may be individually identified as CIRF-repaired items.

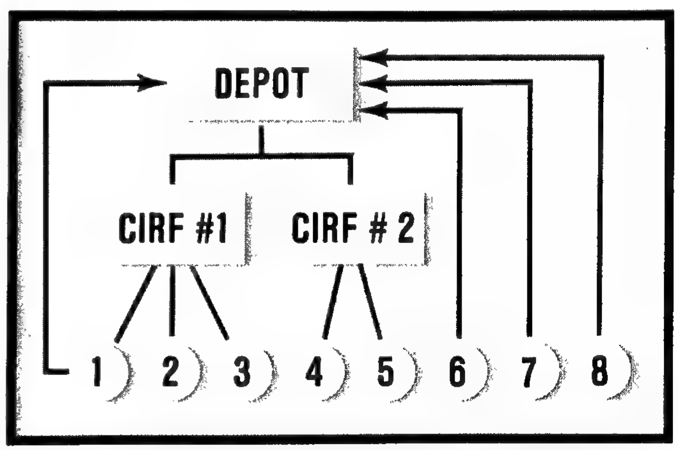

Figure 1: Major Dyna-METRIC Components.

The major material flows modeled in Dyna-METRIC are illustrated in Figure 2. As certain recoverable items fail, they are removed from the aircraft and replaced with serviceable units obtained from base supply. Items which are removed and replaced at the flight line are termed "Line Replaceable Units," or LRUs. A faulty LRU is turned in to base supply. The specific route followed by a faulty LRU depends upon the severity of the defect. If a very simple calibration or adjustment action is required, the repair may be performed in

the base maintenance shops. If a CIRF is used, the more complicated repairs may require that the LRU be forwarded to the CIRF. On the other hand, the most serious LRU repair actions would require the unit to be returned to the depot for maintenance activities. When LRU repair begins, diagnostic equipment may be used in the base repair or CIRF shops to isolate the defective subcomponents. In some instances, these subcomponents—called Shop Replaceable Units, or SRUs—may also be repaired at the base or CIRF, respectively. However, it is more likely that defective SRU units will be forwarded to the next higher echelon in the logistics system for repair.

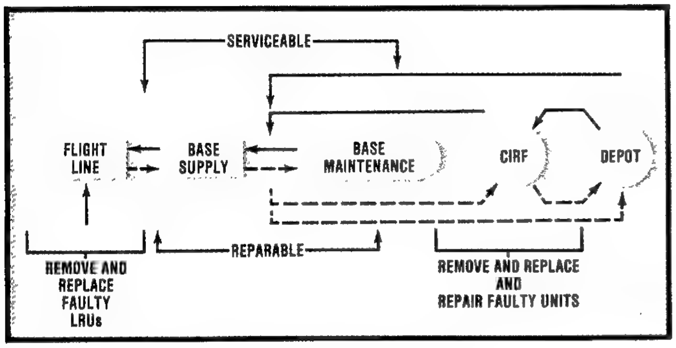

Figure 2: Major Material Flows.

A demand for a serviceable LRU occurs whenever a failed LRU is removed from an aircraft. Once an LRU is removed, base supply must provide a serviceable replacement. If a serviceable spare LRU is immediately available from base supply, the aircraft is returned to an operational condition with minimal delay. If no serviceable stock is on hand, the LRU is placed in a back-order status and repair of the aircraft is delayed. The failed LRU is then either repaired at the base or sent to some higher echelon for repair.

Correspondingly, resupply of base stock can occur in one of several ways. If a failed LRU is repaired at the base, resupply occurs from base maintenance; but if the LRU is repaired at the CIRF or the depot, then resupply will also occur from that location and longer response times will be required due to the longer distances that are involved. In either case, the organization that resupplies the base supply activity does so by exchanging a serviceable part for a failed part on a one-for-one basis. The resupply time (the time it takes to replace an LRU demanded from base supply with the serviceable one) depends on the source of resupply. The amount of time required depends upon the nature of the distribution system linking the base with its resupply source, the amount of repair capability at the higher echelon of supply, and the amount of spares, both of LRUs and SRUs, at the repair locations. In particular, the average time for base resupply of an LRU depends on the availability of SRUs needed to accomplish the repair. If adequate SRU stocks are on hand, repair of the LRU will be completed with minimal delay. However, if repair of the LRU requires the removal and replacement of defective SRU units, the LRU repair cannot be completed until the required serviceable SRU subcomponents have been obtained. Hence, the expected resupply time for an LRU is dependent upon the expected waiting time for SRU subcomponents at the appropriate repair echelon.

Detailed Description of the Model

General Math Model

The basic mathematical theory being used in the Dyna-METRIC model has as its foundation the nonhomogeneous Poisson process. The following definitions will be used:

$X(t)$	=	number of items in the resupply system at time t
$F(s,t)$	=	probability that a service started at time s is completed by time t
$M(s)$	=	item repair demand rate at time s

With the assumptions of excess repair capacity and independence of the repair and demand processes, $X(t)$ has a Poisson distribution with mean $\lambda(t)$ where

$$(1) \quad \lambda(t) = \int_{s=0}^{t} [1 - F(s,t)]M(s)ds$$

This is the basic equation used in Dyna-METRIC. It states that the mean number of items of any one type in resupply at time t is a function of all demands for that item and the capability to repair the items over the elapsed time period. It allows for modeling the intensity of demands as well as the repair capability over time. The ability to control both the demand and repair factors over time makes the model particularly useful to the Air Force for investigating the inventory response to a drastic change to the steady state peacetime conditions, as would occur at the initiation of a war.

The item repair demand rate $M(s)$ is one of the major factors in the Dyna-METRIC model. This rate is a function of many factors; these include aircraft flying hours per day, the average item demands per flying hour, and the percent of fielded aircraft that are equipped with the given item.

The resupply time distribution is a key factor in computing the repair probability $F(s,t)$. As shown in Figure 1, the resupply system consists of three echelons: a depot, centralized repair facilities, and bases. The items in resupply are split into different categories or pipelines that can be identified with echelons. Each echelon has various delays associated with processing items that add to its resupply time. These delays depend upon the echelon, the indenture of the item, the actual mean repair time for the item, the stock levels of the item, and the stock levels of component parts needed to repair the item. These delays, along with administrative time and shipping time, all go into the determination of the resupply time.

Although Dyna-METRIC considers three echelons, it should be noted that the depot is modeled as an infinite source for all items. As a result of this assumption, the optimization and stock requirements calculations ignore the existence of the depot, with the exception of stock required to fill the depot transportation pipeline.

Dyna-METRIC has two options that can be used to specify assumptions for the resupply time distribution. One option is a fixed (nonrandom) resupply time. The other allows the resupply time to be a random variable. The version of the model being discussed assumes that the random component in the resupply time has an exponential distribution. It should be noted here that the model user can specify periods of time when resupply from the depot and maintenance capability at the bases is not available. In addition, other model details may influence the form of the repair time distributions, but these options are beyond the scope of this brief review.

Once the functions M(s) and F(s,t) are specified, equation (1) is used to compute the mean number of assets $\lambda(t)$ in the repair/resupply system at a given time t.

Dyna-METRIC Assumptions for the Distribution of the Number of Assets in Resupply

As noted previously, when demand follows a nonhomogeneous Poisson process, and repair times are independent random variables, the number of assets in the repair/resupply pipeline X(t) is Poisson distributed with mean $\lambda(t)$. However, for other demand processes, the distribution of X(t) may no longer be Poisson. To allow maximum flexibility, the Dyna-METRIC computer code allows the user to specify the variance-to-mean ratio to be used in computing the probabilities of observing differing values of X(t). If the variance-to-mean ratio is specified equal to one, the Poisson distribution is used for probability calculations. On the other hand, the binomial distribution is used for variance-to-mean ratios less than one, while the negative binomial distribution is used if ratios greater than one are specified.

Once the distribution for the number of assets in the repair/resupply pipeline is specified, Dyna-METRIC uses equations defined by Hillestad and Carrillo (1980) to compute ready rates and stock levels for the bases and the CIRF.

Basic Dyna-METRIC Calculation Steps

In the basic Dyna-METRIC model, the first step is to read in basic item data describing the time dependent demand distribution M(s) and the repair time distributions F(s,t). The computation begins. A time loop within the Dyna-METRIC model then computes three average time delay values, which we shall denote as T_E, T_C, and T_S. The first of these delays, T_E, represents the average delays encountered at a specific repair location due to the unavailability of test equipment or spares for test equipment. To compute this delay, a mean value simulation queuing scheme is employed. This presents the user with the option to examine the impacts of test stands on the operation or to ignore this queuing scheme entirely and use the input repair cycle times. Next, the LRU delays (in subsequent model releases, back orders are used) due to the lack of needed SRU spares are computed. Finally, all of these values are combined with projected base repair fraction data to estimate the expected number of assets in the repair-resupply pipeline at the specific time considered in this loop through the calculations. Finally, the model computes fill rates and other stockage measures associated with each LRU and SRU in the system. These item supply measures are then used to compute ready rates, sortie rates, and NMCS (Not Mission Capable due to Supply) rates, and other aircraft readiness measures. Dyna-METRIC then prints these values, and the computations are repeated for the remaining time periods specified by the user.

Optimization

There are several options built into Dyna-METRIC for determining spares requirements. One option allows for satisfying an individual item ready rate criterion on a base-by-base, item-by-item basis. In this case, no optimization is done. Another option calls for stock levels previously determined using the ready rate criterion. It then uses marginal analysis to establish the optimum stock levels across all items at a base to attain a given probability of having less than a specified number of aircraft down due to lack of spares. At this time, Dyna-METRIC does not attempt to trade off spares at the CIRF or depot for spares at the base. The optimization that is performed is done on a single base at a time.

A Sample Output

Dyna-METRIC provides detailed information about logistics system performance at both the item and aircraft levels. Figures 3 and 4 provide a sample of two types of information provided by a set of evaluation runs. Figure 3 illustrates how the ready rate for a particular LRU at a deployed base may behave over time, if the repair cycle time for the LRU is 8 days, intermediate level maintenance is delayed the indicated number of days, and there is then a given stock level. This figure gives a graphic view of the impact of delays in intermediate level maintenance on the item ready rate.

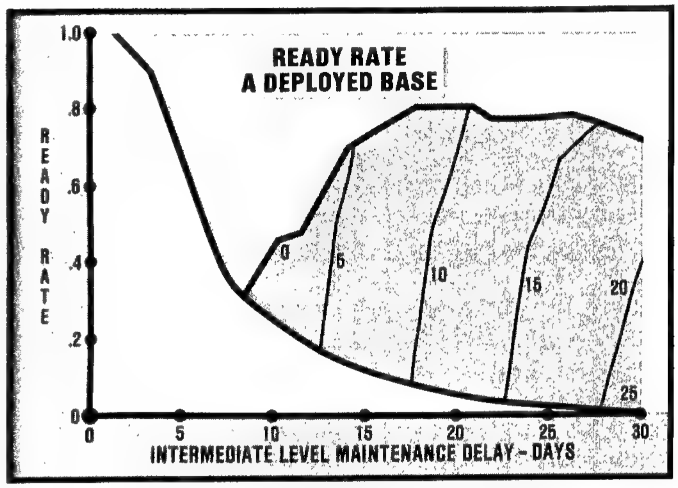

Figure 3: A Sample Ready Rate Projection.

The important contribution of Dyna-METRIC to the evaluation of logistics systems lies in its ability to provide data at the weapon system level. Figure 4 illustrates how the expected not fully mission capable (NFMC) aircraft measure behaves over time, which is valuable to logistics system planners in assessing the impact of delaying intermediate level maintenance to a deployed base.

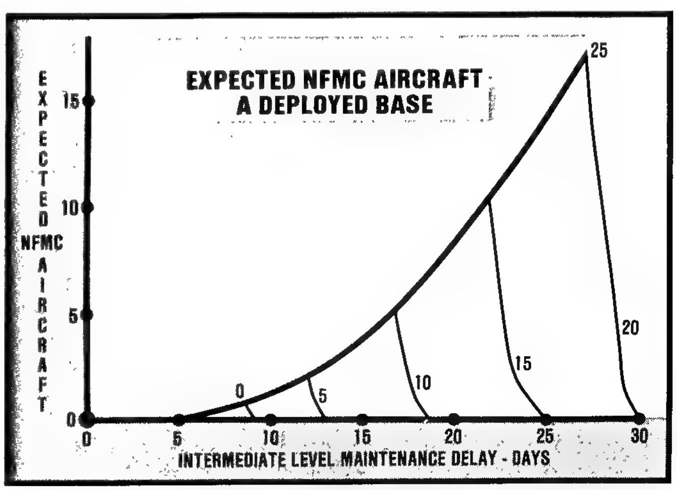

Figure 4: Sample Projection of Expected Number of NFMC Aircraft.

Use in Policy Analysis

As was indicated by the sample data displayed in Figures 3 and 4, Dyna-METRIC provides the planner or policy analyst a

tool for evaluating different alternatives for structuring and operating a logistics system to meet the transient demands of a wartime flying program. Because of its design, the model provides the analyst with the flexibility necessary to look at a host of issues associated with operating a logistics system. Such issues as stock prepositioning, maintenance capability, transportation requirements, and deployment alternatives can be evaluated to project what logistics system configuration and operation policies will best meet the needs when constrained by budgets and other factors.

A Comparison of Dyna-METRIC and MOD-METRIC

As may be seen from the previous discussion, both MOD-METRIC and Dyna-METRIC are based on a similar theoretical foundation. Both consider LRU/SRU relationships in computing the average repair/resupply time for individual items. However, Dyna-METRIC incorporates several features that are not contained in the MOD-METRIC model. Dyna-METRIC considers a three echelon supply system, while the MOD-METRIC model considers a two echelon system consisting of a depot and possibly several bases. The MOD-METRIC model seeks to identify optimum depot and base level stocks of LRUs and SRUs to minimize total base level LRU back orders. MOD-METRIC also relies on stationary assumptions. In contrast, Dyna-METRIC considers a dynamic environment and computes not only LRU base level supply statistics, but also estimates ready rates, sortie rates, and other measures of aircraft readiness. Unfortunately, the additional generality built into the Dyna-METRIC model also significantly complicates the associated optimization problem. Consequently, the Dyna-METRIC model does not perform a system wide optimization. Rather, it is restricted to optimizations of expenditures at a single base and does not consider system wide trade-offs associated with investments at base, CIRF, and depot locations. On the other hand, Dyna-METRIC provides the capability of assessing the behavior of an inventory system in the highly dynamic peace-war transition.

Summary

This paper has attempted to provide a brief overview of Rand's Dyna-METRIC model and make some comparisons between it and the MOD-METRIC model. The usefulness of Dyna-METRIC appears to be in its ability to evaluate the dynamic response of a logistics system when operated in various configurations and under various policy alternatives relating to transportation, provisioning, maintenance, and deployment. It provides performance measures at both the item and system levels which increases its utility as a tool for aiding decision making. It should be pointed out that the version of Dyna-METRIC discussed here is known as Version 3.0 (Figure 5). Rand has since enhanced the model in several areas. These enhancements will undoubtedly increase the utility of the model for both evaluation and item requirements determination.

MODEL RELEASE	RELEASE DATE
2.1	JULY 1980
2.5	NOV 1980
3.1	SEP 1980
3.0	DEC 1980
3.0.1	MAR 1981
3.0.2	APR 1981
3.0.3	JUN 1981
3.0.4	FEB 1982

Figure 5: Dyna-METRIC Models and Release Dates.

The authors wish to thank Curtis Neumann and Mike Niklas from the Directorate of Management Sciences, DCS/Plans and Programs, Air Force Logistics Command, for providing several suggestions for improving drafts of this paper.

Editor's Note: This article on Dyna-METRIC discusses the original, initial model that was released to some Air Force activities at the beginning of calendar year 1980. Since its initial release, the Dyna-METRIC model has undergone extensive revision with the release of eight improved subsequent versions. Although the information contained in this article is somewhat dated, it does provide some interesting insights into the initial Dyna-METRIC model that started the series of releases and culminated in the Air Force standard version that has been documented by the Air Force Logistics Management Center.

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Most Significant Article Award for 1982

The Editorial Advisory Board has selected "The Challenge for Logisticians—The Future" by Lt Colonel Marvin L. Davis, USAF, as the most significant article published in the *Air Force Journal of Logistics* during 1982.

Measuring and Managing Readiness: An Old Problem—A New Approach

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Abstract

The purpose of this paper is to outline some innovative work that has been done at Ogden Air Logistics Center (ALC) that allows us to relate alternative depot level support policies and resourcing commitments for repairable aircraft spares to weapon system combat effectiveness. Throughout this paper—and in the Dyna-METRIC model discussed—the assumption is that the lack of a serviceable recoverable item spare is the only thing that can cause a plane to be "down." To complement what has been evaluated, these analyses need to expand the resources covered to include, among other things, engines, stock fund items, crew, availability, POL, etc. Armed with this information, all the ALCs can assess the impact of policies and resourcing decisions on combat effectiveness. Although our experience in using this new capability is limited, the potential payoffs in aligning depot level decisions to maximize "front-end" combat measures of merit appear to be truly significant.

Overview of Readiness Measurement and Management Concept

There is a growing interest within the Air Force Logistics Command (AFLC) in strengthening our ability to relate support decisions to combat effectiveness. The roots of this interest lie in a general scarcity of resources when measured against requirements and in an increased awareness of the necessity to relate those resources to system-oriented readiness outputs. A tangible expression of this interest has been the establishment of an AFLC-sponsored meaningful measures of merit (M^3) program. The purpose of this program is to develop a predictive capability for the AFLC Commander that will demonstrate weapon system impacts of alternative support policies and resource levels. If such capability can be provided, it could be a key step in enhancing AFLC effectiveness and improving support to the major commands (MAJCOMs).

The Measurement Concept

In coming to grips with the problem of how logistics resources can be related to combat effectiveness, several questions need to be addressed:

(1) What measures of merit of combat effectiveness should be used?

(2) What should the goals be?

(3) How do logistics resourcing decisions impact these measures?

On the surface, these questions seem formidable indeed. However, existing planning processes provide the answers to these questions. The major hurdle to overcome is to establish a technique which relates these processes to one another and to the same measures of merit.

Our concept begins with the premise that the adequacy of logistics support should be measured against the various wartime and peacetime weapon system performance goals. In other words, weapon system performance goals are the meaningful measures of how well the base and depot level supply, maintenance, distribution, and procurement functions are meeting their mission requirements. In and by themselves, the logistics functional measures that have grown up over the years, such as fill rates, back orders, percentage of on-time deliveries, etc., are not adequate measures of performance. The functions of logistics need to be measured according to their impact on front-end measures of merit; e.g., weapon system performance.

Considering this premise, an important first step then in developing a logistics performance measuring system is to come up with a universally agreed upon measure of weapon system effectiveness. Fortunately, for aircraft systems, these measures have been developed and agreed upon, although perhaps not explicitly. The important measures for aircraft systems are the number of mission capable aircraft and sorties that are called for in various war plans or MAJCOM peacetime sortie utilization goals. Thus, the requirement of the logistics system is to make aircraft available to generate sorties during peacetime and wartime (surge and sustaining rates). The measure of logistics performance then becomes one of how many available aircraft and sorties the support structure can generate for any given scenario.

The problem becomes one of relating various logistics subsystem performances against sortie or available aircraft requirements. While this is not an easy problem to solve, the fabric of how to tie the support structure to this measure exists. Just as the war plans and MAJCOM peacetime sortie goals provide the answer as to what the measure of logistics performance should be and what the specific goal in terms of that measured is required, the logistics requirements determination processes *implicitly* indicate the levels of logistics support we are planning to provide in wartime and peacetime. Therefore, the problem confronting us becomes one of aligning our requirements process measures of merit to indicate the number of aircraft we are *explicitly* planning to have available to generate sorties. Once this is accomplished we can assess if our planned levels of support are consistent with the operator's planned mission.

Consider our aircraft spares requirements system. Until recently, we planned peacetime spares levels to meet particular fill-rate goals. The factors used in computing spares requirements indicate what we planned to have as the base repair time, transportation times, failure rates, etc. Similar factors are used in our wartime spares requirements computations. Thus, we have *implicitly* stated our planned wartime and peacetime logistics performance. All that is required to measure the effectiveness of logistics support is to align the fill-rate goals with the resulting aircraft availability or sortie generation goals and measure actual logistics performance against the plan. For example, what is the actual repair time versus the planned? If it is longer, do we need more assets or can we shorten another pipeline to compensate? Given this philosophy, one can begin to relate the measures of

each logistics function to aircraft availability and set about to measure performance against that which had been implicitly planned.

The Technology

Adopting this measurement philosophy, we developed the modeling technology (Dyna-METRIC) necessary to implement the concept.* Dyna-METRIC uses analytic techniques that capture the flying operations of an operating base or set of bases in sufficient detail to permit estimating how recoverable spares levels, repair times, and transportation times will impact aircraft availability or sortie generation capability. Dyna-METRIC uses a turn rate for each available aircraft to determine how many sorties can be generated. This turn rate is a function of a large number of factors including types of missions being flown, massing requirements, enemy defenses, etc.

The capability assessment model is the keystone in the concept because of its ability to relate several important aspects of component support to aircraft availability. Dyna-METRIC was designed to be a flexible tool which can examine several "what if" questions. Among the variable input parameters which can be changed are the scenario, aircraft beddown structure, component reliabilities, repair capability, transportation capability, stock levels, and flying programs. Because Dyna-METRIC forecasts these factors' effects on combat capability, it affords us an opportunity to examine cross-functional resourcing tradeoffs. Because it incorporates wartime dynamic changes in aircraft beddowns, flying programs, attrition rates, and support capability, it facilitates the analysis of complete wartime phased deployment plans or the peacetime deployment of newly acquired aircraft.

Using the new technology to measure and manage readiness required several inputs to conduct readiness assessments of logistics support. These inputs consist of logistics, operations, and deployment data. The model requires moderately detailed information in each category. For instance, the model needs to know the components on the aircraft, the component's failure rates, base and depot repair times, and stockage at each base and depot for each item of interest. Further, it needs the relevant unit's operational deployment and employment plan, including the number of aircraft at each base, the number of sorties per day, and the average flying hour duration of each sortie. Finally, it needs information on how the support system resources and capabilities vary over time, including when repair becomes available for deploying units and when resupply becomes available.

Though these data are voluminous, they need not overwhelm analysts using the system. Most of the data are routinely measured, computed, and managed by existing standard AF systems. Thus, one can develop preprocessors to convert those systems' data into a form for use by Dyna-METRIC.** Basically preprocessors strip logistics data for each item used in the weapon system being evaluated from existing data sources.

*Hillestad and Carrillo (2) first outlined the relevant mathematics. Hillestad (3) refined those mathematics to provide the basis for the current model's basic capabilities. Pyles (5) described those capabilities nonmathematically and demonstrated how logisticians can use the model to analyze component support issues.

**Tripp and Hales (7) have developed a preprocessor for War Readiness Spares Kits, Base Level Self-Sufficiency Spares (WRSK/BLSS), and Peacetime Operating Stock (POS) for their analyses. The Combat Supplies Management System (9) will routinely develop Dyna-METRIC input data that reflects current stock asset disposition at the base level. The PACAG Combat Support Capability Management System (6) measured component intermediate level process times and resupply times.

The model's outputs are both aggregated and detailed. Primarily, the model forecasts available aircraft at each base. But it also pinpoints problem items and processes that somehow limit that capability. Therefore, more detailed information is useful in developing get-well plans and workarounds.

The Needed Capability

As the AFLC agent accountable for insuring the supportability of the assigned weapon system, the responsibility for conducting these assessments falls on the shoulders of the AFLC system manager (SM). The specific capabilities that are required by the SM to conduct readiness assessments and manage aviation spares are:

(1) To compare readiness outputs (e.g., numbers of partially mission capable (PMC) aircraft and numbers of fully mission capable (FMC) aircraft) of PLANNED spares support for a given aircraft type against readiness requirements inherent in planned peacetime flying programs and wartime scenarios.

More specifically, the SM would use the model to:

— Assess capability of logistics support system to meet operational requirements (in terms of aircraft availability) and point out discrepancies to MAJCOMs and HQ AFLC to facilitate corrective action.
— Identify specific problem items which limit attainment of planned operational goals.
— Develop alternative support options, if needed, to meet readiness goals.

(2) To compare readiness outputs of ACTUAL* spares support for a given aircraft against PLANNED readiness support to detect and diagnose circumstances where support is currently not achieved. As with PLANNED support, the SM would develop problem parts lists and possible workarounds based on this analysis.

(3) To identify the best source (worldwide) to provide required support for special force deployments with minimum impact on readiness outputs Air Force wide.

(4) To develop alternative strategies to alleviate spares shortages by reducing transportation times with special arrangements, augmenting base repair capability to reduce repair times, and reducing depot flow through times (priority repair).

Since the development of this capability, several analysts have used Dyna-METRIC in some supportability analyses of various weapon systems. To show how the system can be used to enhance support, we will now present only one example of how we have used Dyna-METRIC to improve the supportability of the F-16.

An Example: F-16 Quarterly Spares Assessments

An overall theme of the Ogden work has been to imbed the use of an analytical tool (Dyna-METRIC) in a live management structure. That work's emphasis has been to use initial analyses to improve support, but it has also focused on determining information and organizational support structures which are required to institutionalize the use of this and other analytical tools in the ALC environment. Thus, we first describe the F-16 example below; then we describe issues related to its ultimate ongoing use.

*These sets of analyses differ from the PLANNED evaluations in that they take actual logistics peformance (e.g., actual spares procured, actual repair times, etc.) vis-a-vis those that were used for logistics resourcing decisions (i.e., the planning factors).

Several factors led to the F-16 quarterly spares assessments. Both the technology (Dyna-METRIC) and senior management interest had developed which related logistics postures to combat capability. Several important changes in planned F-16 logistics support had occurred that were significant enough to have senior military leaders seriously question the spares supportability of the F-16. Among these were reduced funding of spares for the F-16, changes in USAF deployment plans which were the basis for initial spares provisioning of the F-16, and added foreign military sales (FMS) cases that were not foreseen when initial spares were stocked.

Given these major issues and the climate to gear AFLC support to combat readiness, a serious effort was undertaken at Ogden to assess the supportability of the F-16. The effort was led by the F-16 SM with the active participation of the tactical air forces (TAFs). The following sections identify how the problem was attacked.

Designed Solution

The first goals of the spares assessment were to determine: (1) how well available peacetime operating stock (POS) and war reserve materiel (WRM) support flying objectives in peacetime and wartime; (2) what items limited attainment of flying objectives; and (3) what could be done to alleviate these problems. To obtain quantitative answers to these questions over a fairly long period (three years), Ogden ALC decided to use Dyna-METRIC.

Let us point out some of the unique aspects of this analysis. First, this analysis examined total worldwide F-16 performance across all commands and related how all levels of the logistics system concerned with recoverable spares interact and impact weapon system support. The analysis linked together the impacts of stockage, base and depot repair capability, and transportation capability between the base and depot systems. Another unique feature was the extended time horizon. This aspect of the analysis gave us the ability to evaluate peacetime supportability in terms of NFMC aircraft at quarterly intervals. This capability is extremely important cause it provided the ability to examine long-term changes stockage, reliability enhancements, and other corrective actions already underway and examine those impacts at the proper lead time. This extended time horizon also gave us the ability to evaluate wartime supportability during any particular quarter we wished during the three-year time horizon.

This analysis gave the F-16 SM, for the first time, a data bank consisting of all recoverable items used on the F-16. This required obtaining input data on these items from each of the five ALCs who are involved with managing items used on the F-16. Thus, on the output side, the analysis provided the F-16 SM with information on all recoverable items—no matter where they were managed—that limit NFMC rates.

The analysis used the process shown in Figure 1. After using Dyna-METRIC to predict aircraft performance, that performance was compared with the Tactical Air Command's established goals. If no significant differences had arisen between the predicted capability and the goal, no further action would have been necessary. But if the predicted aircraft availability fell short of what was required, the model generated a list of problem items for the SM to begin troubleshooting. Special studies then must be initiated to determine if the bad actors need to be reengineered or if repair times can be reduced or transportation can be lessened. (The results of these off-line efforts impact item characteristics like

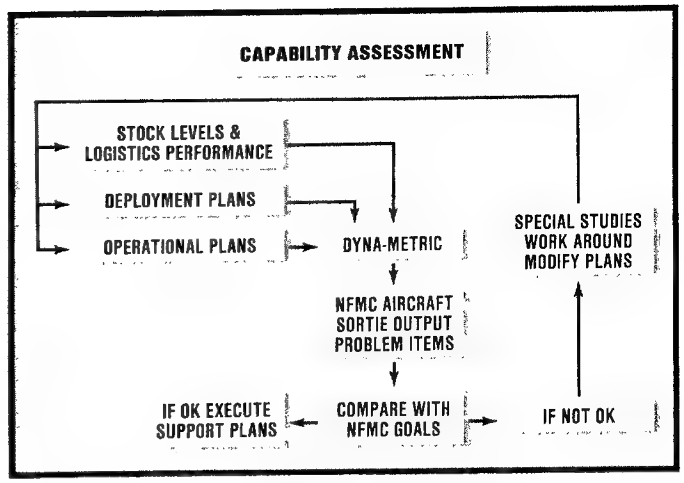


Figure 1. Dyna-METRIC Assessment Schematic.

failure rates, repair times, etc.) Once changes in factors are proposed, their impact on combat capability can be evaluated with the model. If the plans then achieve the readiness goals, the cost to achieve the improvements can be weighed against the readiness benefits and against each other. This circular process repeats until combat goals can be met or logistics constraints impact deployment plans.

Inputs and Outputs: Comments and Illustrations

In a previous section, we mentioned the major types of inputs and outputs of this Dyna-METRIC application very briefly. This section will expand that discussion to give the reader a greater appreciation of the major types and sources or data and outputs. Figure 2 shows some of the major data elements which were required to conduct the F-16 quarterly spares assessments. The list is not exhaustive but serves to illustrate the types of data required.

EXAMPLE INPUTS

SOURCE	DATA ELEMENTS
• WARPLANS, PROGRAMMING DOCUMENTS	• BEDDOWN STRUCTURE, SORTIE • REQUIREMENTS, ATTRITION RATES
• INTEGRATED LOGISTICS DATA FILE	• LRU/SRU RELATIONSHIPS
• REQUIREMENTS COMPUTATION SYSTEMS	• DEMAND RATES* • ORDER AND SHIP TIMES* • REPAIR CAPABILITY* • REPAIR TIMES*
• STOCK BALANCE AND CONSUMPTION SYSTEM	• AUTHORIZED STOCK LEVELS* • ON-HAND QUANTITIES*

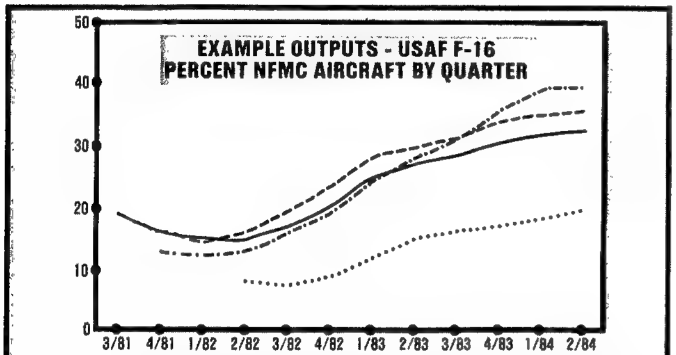
*JUST AS DYNAMIC AS FORCE MOVEMENTS & REQUIREMENTS

Figure 2.

War plans and programming documents provide the goals to be obtained (i.e., sorties in wartime or NFMC rates from MAJCOMs in peacetime) as well as the beddown structure, sortie durations, and attrition factors. In this analysis, we generated the smaller of the sorties required and the maximum number that could be generated (i.e., if only one plane was available it flew up to the maximum turn rate per day). As we have stated previously, this could be a misleading number and available aircraft may be a more meaningful number. Dyna-METRIC directly considers the indenture relationships of subassemblies to assemblies (LRU/SRU), so these parent-child groupings must be together. Demand rates, repair times, and other item characteristics were taken directly from our D041 requirements computation system for peacetime assessments

and the D029 WRSK/BLSS computation system for assessments of the first 30 days of wartime support. Authorized and on-hand quantities of assets by base are picked up from the Stock Balance and Consumption Report for peacetime operative stocks and manually adjusted as required to compensate for multiple user items. WRSK/BLSS authorized and on-hand quantitives are manually prepared from requisition schedule data.

Figures 3, 4, and 5 show some of the major outputs of the F-16 quarterly assessments we use. Figure 3 shows projected peacetime NFMC rates over a three-year period. The chart shows the worldwide average NFMC rates and compares each MAJCOM's NFMC rate against that average. These aggregate statistics can be used to compare rates by MAJCOMs and thereby provide management information which could possibly be used as the basis for allocation or redistribution decisions.



USAF %	19.1	16.2	15.3	15.1	17.2	20.4	25	27.3	28.6	30.5	31.7	32.4	———
TAC %	19.1	16.5	14.6	16.2	19.4	23.4	28.4	29.9	31.5	33.9	35	35.4	- - -
USAFE %				8.3	7.6	8.9	11.9	15.2	16.6	17.3	18.4	19.9	.....
PACAF%		13.1	12.4	13	15.8	19.1	24.5	28.2	31.1	35.6	39	39.3	-.-.-

Figure 3.

EXAMPLE OUPUTS
PEACETIME PROBLEM ITEMS SHORTFALL IN 3 YEARS

WUC	SYSTEM	NOUN	ALC	MIN QTY	MAX QTY
11ACA	AIRFRAME	DOOR ASSY	OO	7	33
13CAG	LANDING GEAR SYS	NLG DRAG BRACE ASSY	OO	8	8
13EAF	LANDING GEAR SYS	ANTI-SKID CONTROL BOX	OO	7	33
231FA	TURBO FAN PWR PLANT	DETECTOR: ICE	SA	10	44
24AAO	AUXILIARY POWER/JFS	TURBINE POWER UNIT	SA	23	31
24BEO	AUXILIARY POWER/JFS	VALVE, BLEED AIR REG	SA	6	8
24DCO	AUXILIARY POWER/JFS	CONTROLLER/JFS	SA	9	28
24DDJ	AUXILIARY POWER/JFS	HYD DOOR CONTROL VALVE	SA	7	7

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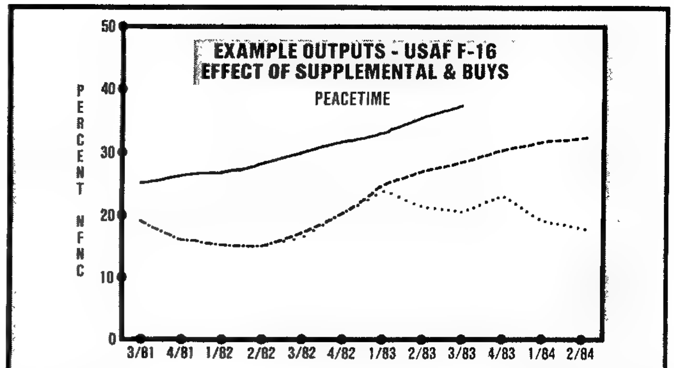
Figure 4.

Figure 4 is an example of some of the problem items which will probably cause the peacetime NFMC rates to be above the SM's target of 15% NFMC aircraft. This objective was established by the F-16 SM and is not a formal Air Force standard. This article makes no attempt to establish the reasonableness of that value. The output allows us to see which ALC has the item management responsibility for this item and what the minimum and maximum shortages of the item happen to be over the time horizon. The SM can use this information to begin to track down potential future problems and propose get-well actions before those problems become overwhelming.

Figure 5 shows an output of how projected NFMC rates for the fleet are affected by actions taken by the item managers (IMs). The chart indicates that recent IM actions, including buy actions, will reduce expected NFMC rates in about two years (procured items enter the inventory). The dotted line



SEP DATA	25.2	26.5	26.9	28.3	30.1	31.7	33.2	35.7	37.4				———
MAR DATA	19.1	16.2	15.3	15.1	17.2	20.4	25	27.3	20.6	30.5	31.7	32.4	----
WITH SUPPL	19.1	16.2	15.3	15.1	16.7	20.4	24.1	21.5	20.9	23.2	19.3	10.1	.....

Figure 5.

shows the impact of F-16 FY81 supplemental spares funding, which was received to offset some of the funding deficits seen in previous years.

Implementation Issues

There are several strengths of the F-16 quarterly spares assessments. The assessments relate logistics system performance and resourcing decisions to combat capability measured in terms of available aircraft and achievable sortie rates. The technique also deals with base and item level data, or in the case of WRSK, squadron level. Therefore, problems can be isolated down to the item, and squadron or base level. The approach also deals with interactions between the base and depot level transportation, maintenance, and supply systems.

Another strength is that the assessments look at the total force of F-16s worldwide and not just at squadrons or theaters. Finally, the assessments explicitly deal with the dynamics of a changing world over a relatively long span (three years).

The assessments have also been conducted with the direct involvement of the tactical air forces (TAFs). In fact, Dyna-METRIC has been selected by the Air Force to be used as the official capability assessment model for tactical aircraft applications. The Air Force Logistics Management Center (AFLMC) has been given functional management responsibilities for the model and is presently accomplishing necessary validation and documentation. The standard Air Force version of the model will be initially embedded in the Combat Supplies Management System along with required pre- and post-processors. Expansions to the model's capabilities will be worked through a Dyna-METRIC users group. The assessments to date have been accomplished with a nonstandard version of the model, but have been embraced enthusiastically by the F-16 SM and have been included as part of the Weapon System Program Assessment Review (WSPAR), which is presented quarterly to HQ AFLC and HQ USAF.

On the other side of the ledger, there are several things that could be done to improve the F-16 spares assessments program. We need to extend Dyna-METRIC to more closely model the impacts of depot level performance on combat readiness. We need to know the time-phased repairable workload coming into the various depot shops for items. We also need to know the capacity of the depot shops to handle this workload and how capacity constraints impact combat readiness. Armed with this information, we can size our depot

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Dyna-METRIC: A Valuable Management Tool

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Abstract

Currently, there is widespread acceptance of the need to develop practical tools to translate specific logistics information into measures of Air Force operational capability. The resulting measures of capability can then be compared to existing standards or goals to establish the contribution of logistics resources to Air Force operational readiness. This kind of information has become critical for determining the effective and efficient allocation of scarce resources to support our war-fighting tasks. One of the most notable efforts in this area is the Rand-developed Dyna-METRIC model which translates logistics spares information into capability assessment outputs. Although the model has been extensively used by various MAJCOMs, little has been done to document its internal processes. This article presents some of the findings of the Air Force Logistics Management Center (AFLMC) study which evaluated the internal programming and documented the Dyna-METRIC processes. This general overview extends into a description of the internal functions of the model, its outputs, and its limitations.

Dyna-METRIC Internal Functions

Dyna-METRIC is a large (15,000 lines of code) FORTRAN model designed to depict the dynamic wartime behavior of repairable item stocks. It determines either the optimal stockage for supporting a fixed sortie rate or the maximum sortie rate attainable with given stockage. In doing so, the model produces a number of output products consisting of information on performance, problem parts, pipeline, and :kage. Of primary concern in assessing unit capability is the performance information and problem parts information. We will discuss the output and how the Dyna-METRIC model computes the capabilities in the following paragraphs.

The Dyna-METRIC model considers an aircraft to be nothing more than a collection of spare parts, each of which is waiting to fail. The operational mission is considered only to the extent that it requires numbers of aircraft and causes items to fail. Each part is considered essential in that its failure will necessitate replacement of the part. If a replacement part is not available, the aircraft is considered Not Mission Capable due to Supply (NMCS) until the part is available. Parts composing the aircraft are considered by the model to be either Line Replaceable Units (LRUs), which are composed of a carcass and one or more Shop Replaceable Units (SRUs), or SRUs. In calculating performance, the Dyna-METRIC model calculates broken aircraft based on two cannibalization options. Cannibalization of parts from one aircraft to another is either prohibited (no cannibalization mode) or is accomplished as necessary to support mission objectives (full cannibalization mode).

The model can handle a wide variety of configurations from a single base to a multi-base theater. Each base has an in-house repair facility which may have various test and repair capabilities. This base repair facility may be augmented (though it is not necessary to run the model that way) with a Central Integrated Repair Facility (CIRF). An example of the possible structures is depicted in Figure 1. In this example, there are three bases, each with an in-house base repair facility. Two of the bases are associated with a CIRF while a third base is not. The arrows represent the flow of parts to and from the various structures. Note that all parts flow through base repair. It is only after base repair that the parts are either repaired or shipped off to the depot. A depot is represented as existing outside the model. It is seen, from the model's point of view, as an infinite source of supply located some order and ship time away. As part of the user input into the Dyna-METRIC model, the order and ship time is designated for each part by the user.

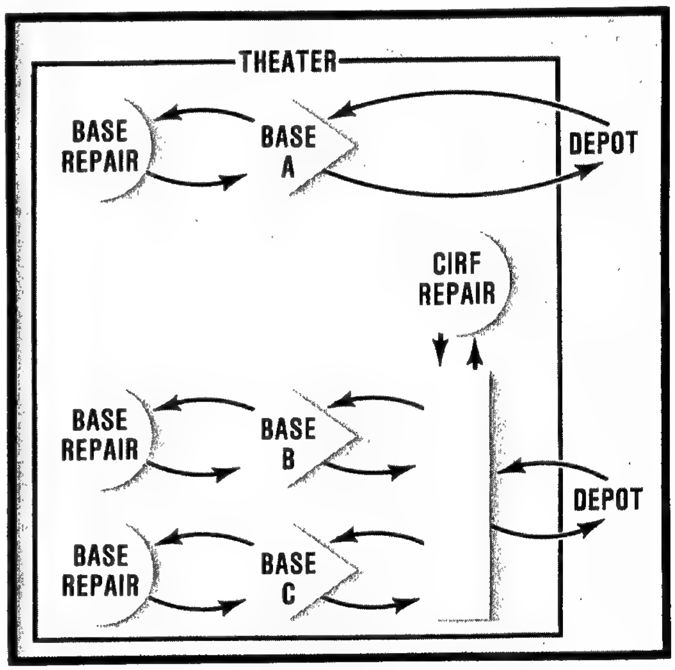

Figure 1: Dyna-METRIC View of the World.

The actual focus of the model is on the set of repair facilities and arrows in the diagram (in other words, the pipelines). The level of each part in each pipeline is calculated for a given day. These parts are then considered to be not available for use on an aircraft. These aggregate numbers are then subtracted from the total number of parts of each type which are available to determine the number of mission capable aircraft for that day. Those aircraft that do not have any holes are then used to "fly" the required number of sorties as defined by the user.

There are two things to remember when looking at the model operations. The first is that the model does not consider a variety of other related issues such as crew or bit and piece availability in determining mission capability. If the aircraft is mission capable, in that it has no requirements for the spares that are being modeled, then the aircraft will be flown as

needed. Second, although we talk of individual aircraft, the Dyna-METRIC model actually *never* looks at individual aircraft. The number of grounded aircraft is determined by probable distributions of holes across all weapon systems at individual bases.

Dyna-METRIC Outputs

The Dyna-METRIC model creates a great deal of information with each model run. There are different types of data available out of the Dyna-METRIC model, including information on performance, stockage, problem parts, and pipeline. The types of output can be specified by the options selected by the user and displayed for each day that is input by the user. In addition, the model can address test stands and compute information relating directly to their operations. However, within the confines of this article, it is not possible to discuss each field output by the model. We will, however, describe the two major fields that are most used in the analyses to date: the performance information and the problem parts information.

Performance Information

The Dyna-METRIC model provides the user three pieces of performance information for each day specified by the user. The NMCS aircraft, the number of sorties flown, and the total back orders are displayed for each time period desired by the user. The user may select this output information for a variety of time periods, and these same fields are displayed on each day selected.

The NMCS aircraft levels are computed by the model under two possible assumptions: full cannibalization or no cannibalization. Under each assumption, the model calculates the expected number of NMCS aircraft (the mean value) and the standard deviation (or the dispersion of values about the mean). The NMCS figures are meant to be taken in a probabilistic sense. The numbers are calculated from a probability distribution, rather than representing an absolute value. Using the mean value plus the standard deviation provides a more accurate view of the band of possible values that Dyna-METRIC has actually provided.

The sorties are also calculated by the model as a mean and standard deviation, and they are arrived at in much the same manner as the NMCS aircraft. The sortie values are based only on the full cannibalization assumption for generating the most available aircraft and represent only one day's missions. In other words, the sortie values are not cumulative. Again, the values are calculated rather than absolute.

The final piece of information within this portion is the total number of back orders. Dyna-METRIC merely accumulates the number of expected holes in the aircraft to come up with a total back order figure. The value of this entry is that more detailed data can be called (in the pipeline information options) if the total back order figures grow too large. This figure can then be used as a key in determining when additional information might be desired.

With these three fields of information, the Dyna-METRIC model provides the user an indication of logistics supportability. However, the values are not nearly as firm or absolute as they might appear. The information represents bands or ranges of values rather than certain events. In addition, a number of key assumptions presented in the final section may significantly influence the results.

Problem Parts Information

The problem parts list is generated based on the performance goal that the user inputs and the number of problem parts desired to be output—again, specified by the user. A problem parts list will be created at each time of analysis where performance information is required providing that the performance goal specified by the user cannot be met. Otherwise, there will be no problem parts list produced. The items contained on the list will only be the major components (LRUs). No subcomponents (SRUs) will be listed. The model will identify the part and the number of holes created by that part.

While the problem parts list demonstrates that shortages exist, where the shortage is or what caused it requires additional analysis. The problem parts list should not be taken at face value. Any number of factors might be a contributor to the parts shortages. Incorrect assumptions concerning the failure rates, prolonged maintenance deployment and set-up times, long repair times, low stock levels, low on-hand quantities, long administrative delay times, etc., might cause the shortage. In addition, the problem part might be caused by shortages of SRUs or bit and piece failures.

The thrust of this discussion has been to demonstrate that the problem parts list is only a starting point. Incorrect assumptions or various pipeline problems might be generating the problem. A review of each area might reveal that stock levels are not, in fact, the contributor to the out-of-stock conditions.

Dyna-METRIC Limitations

Every computer model is built on some assumptions. The importance of understanding the major assumptions is that such knowledge enables the user to determine when the foundation of the model has been violated and to assess the impacts on the outputs. Perhaps the two major underlying model assumptions are that the spares input into a particular model run comprise all events that might ground aircraft and that all information input by the user is correct. However, there are eight major assumptions described in this section which are essential for the user to understand before assessing the capability of any unit.

The actual sorties will never exceed the demanded sorties. In the Dyna-METRIC model, the user establishes a scenario demanding certain sortie levels. The model then computes what can actually be flown given the various stockage and operational constraints. The model will *never* exceed the demanded level requested by the user. What this creates is the impression, when the results are graphically set against the demands, that the unit in question can barely support the demanded mission. However, in fact, the unit might well be able to support many more sorties.

Demanded sorties, not actually flown sorties, determine the consumption of spares. The Dyna-METRIC model uses the employment plan input by the user to determine the number and types of spares consumed. The model uses the number of sorties that are *planned* to be flown combined with the demand rate information to determine how many of each part will fail. If the actual number of sorties that can be flown by the fully mission capable aircraft falls below the desired or planned number input by the user, the model will continue to consume spares as though *all* of the required missions were, in fact, flown. In other words, the aircraft that are down for parts,

listed as NMCS, continue to consume spares as though they were flying their missions.

The NMCS figures do not necessarily mean grounded aircraft. The model assumes that any aircraft with a hole in it, that is a lack of one or more parts, is grounded and unable to perform any missions. Partially mission capable aircraft are not currently considered under the Dyna-METRIC model. As a result, the NMCS figures might be misleading in that they might be overstated. Some analysis might be necessary to determine which parts, in fact, ground aircraft.

There are ample repair facilities to perform all repair operations. For the main cases in which the Dyna-METRIC model is run, the model assumes that no backlog ever develops in the maintenance shops. Maintenance is never overwhelmed with large numbers of repairable items. In the model, each broken part is immediately assigned to an available maintenance technician who then begins repair. There is a portion of the Dyna-METRIC model devoted to test stands. This subroutine, in effect, is a queuing model with which to evaluate the effect of backlogs on the test stands. However, this subroutine has not been used extensively due to lack of data.

The repair and demand processes are independent. In Dyna-METRIC, the flight line, the repair shops, and base supply operate independently of one another. The repair shops repair strictly on a first-in, first-out basis without regard to the balance of stock in the supply warehouse of the item or requirements for the grounded aircraft on the flight line.

Demand rates vary only with flying intensity. The model assumes that there is a linear relationship between the amount flown and the mean number of parts that break. In other words, the mean number of parts you break is a constant times the total flying hours. There is no other factor that impacts on the break rate. Dyna-METRIC does employ a variable called "linear" that can be used to increase or decrease the failure rate to flying hour ratio, but the linear relationship between demands and the flying program will remain intact.

The depot is an infinite source of stock. The Dyna-METRIC model assumes that every requirement generated against the depot will be supplied according to the probability distribution of the order and ship time that has been input by the user. There are no out-of-stock conditions at the depot.

The CIRF pipeline distributes stocks to bases based on cumulative flying hours. The CIRF sends parts to the bases strictly according to the cumulative flying hours of each base. The more a base flies in relation to the other bases supported by the CIRF, the more stocks are shipped into it by the CIRF. This policy is embedded in the model and cannot be changed by the user. This assumption might become more important as more activities seek to use the CIRF to model the standard depot.

Conclusions

Dyna-METRIC is a valuable management tool—a key means of assessing the capabilities of individual flying units or entire wartime theaters. This model depicts the impact of logistics resources on operational scenarios and then describes those impacts in terms that the Air Force manager can use to resolve potential support shortfalls.

The Dyna-METRIC program output, however, is not a final truth. The model, of necessity, makes a number of assumptions; and its results are subject to several limitations. These outputs must be continually reviewed against the model inputs, operations, and assumptions to assure their validity and reasonableness. Where the model fails to accurately portray the operational or support scenario, whether in its operations or assumptions, the validity of the output should be questioned.

Increased use of the model to brief and to explain support problems makes model education essential. It is imperative that all personnel involved with Dyna-METRIC results—from the analyst to the decision maker—understand the Dyna-METRIC model operations, outputs, and key assumptions. While we have tried to shed some light on the Dyna-METRIC model, each manager in the Dyna-METRIC informational chain should become familiar with the actual model. For, only through an understanding of the Dyna-METRIC model, can Air Force logisticians make intelligent and discriminating decisions concerning the final output of the model and its relevance and applicability to operational scenarios.

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repair capability necessary to achieve combat goals for various scenarios. We are currently working on developing the extensions. Finally, we need to expand the system to include other logistics resources, such as those at the flight line.

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Coming in the Summer Issue

- **Movement Control: Enhancing Contingency Resupply**
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The Military Leader - A Manager of Communication (The Feedback Process)

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Humans have been able to subject this earth to their will and develop a life style of relative luxury and accomplishment. A basic building block for these achievements is the mentality inherent to the human brain, a capacity to conceptualize and communicate. Because humans have the capacity to think, in both abstract and concrete terms, they are able to reflect on the past, evaluate the present, and visualize the future. Thus, they can create needs and the means for satisfying them. However, most of the thoughts of men are beyond their capability to fulfill alone, so they seek the assistance and cooperation of others to succeed in dream realizations.

In addition, communication among humans assumes a major role in individual and societal improvement. Improvement through change and progress could not occur purposefully without effective communication. Our whole scheme of resource management and the teaching of people rests on the God-given capability to convert ideas to symbols and symbols to meanings.

Humans communicate in a variety of ways: speaking, listening, writing, reading, and signaling. In our modern society, all of these are widely used to disseminate ideas, obtain results, and create new concepts and desires. The military leader, not unlike his civilian business contemporary, finds a major element of his success to be the ability to use these ways to meet organizational and personal responsibilities. Heavy emphasis is placed on the skill of their use in schools, in training programs, and on the job through a range of evaluating processes.

In general, the most effective interpersonal communication is two-way communication. Two-way, as opposed to one-way, demands the active participation of both parties (the sender and the receiver) in a give-and-take arrangement wherein each party encourages, and responds to, the other. Each tries to transmit to the other his perceptions and understanding of the other's message. This dynamic involvement continues until they reach a commonly understood set of actions, responsibilities, and results.

Military organizational functioning, based as it is on a traditional order-giving hierarchical arrangement, is not always receptive to, or encouraging of, two-way communication. Far too often, military communication is predominantly one-way, with the idea "I direct and you perform." This was no doubt a vital part of military effectiveness years ago when the bulk of the force was poorly educated and not strongly aware of any other way to accomplish tasks. However, today's military force is quite different; therefore, the communicative techniques of the military leader must also be quite different. Perhaps the greatest need for improvement is in that area of the process identified as feedback.

Feedback concerns obtaining and using information about the effectiveness of earlier transmitted messages. Its purpose is to assure that all transmissions can be better formulated and improved, whether sending new information or altering old information. This article offers some ideas about feedback. It is specifically directed at communication between the superior and subordinate in a military organization. It concentrates in particular on the actions of the superior. It is designed to help you, the military leader, improve the feedback process in your communication with people. The rules which follow are not absolute, but they are intended as guides and must be adjusted to the situation. For that reason, cautionary measures have been included to help you apply the guidance.

Guidelines

(1) In written communication, ask other people to critique or question your draft if time permits. The more critiques you obtain before final copy, the more you learn about how to write a clear and concise message. *(CAUTION: Be careful in your selection of people for this task. Do not use a "yes" man for obvious reasons.)*

(2) In oral communication, ask the other person to explain what you have just told him. Do this often enough to gain an understanding about methods, time, costs, results, etc. *(CAUTION: Do not do this in such a way the other person feels you consider him to be incompetent or of lower intelligence. In other words, be understanding, empathic, courteous, and skillful.)*

(3) A misunderstood communication is usually blamed on the receiver first. He may be partially at fault; but, you, the transmitter, might also be at fault. It is far easier for you to improve yourself than to improve another person. If you must send a message to get a job done, you really are the one responsible for the job's success or failure. *(CAUTION: Blaming the other person does not alter your responsibility. Improve your own ability to transmit and to acquire the feedback you need for successful communication.)*

(4) Do not allow a misunderstanding to exist for long. As soon as you recognize a garbled message, earnestly work with the other person to clear the air. Put him in a supportive, rather than defensive, position and he will be more cooperative in solving the problem. *(CAUTION: Do not let misunderstandings go uncorrected. Work on them right now!)*

(5) Work hard to acquire a reputation for fairness, loyalty, and sincerity. That reputation will do a lot to decrease misunderstandings because the other person will recognize your efforts and be better prepared for

two-way communication. *(CAUTION: Two-way communication must include feedback in both directions until an understanding is acquired. It will not always be fast or easy.)*

(6) Deal with the individual first and not with the group when a misunderstanding occurs. The problem may lie with just that one person. *(CAUTION: Determine the most likely person to misunderstand the messages and work with him for clarity. Then, if necessary, work with others for the same end. This is time-consuming, but it also helps to strengthen your reputation for fairness and sincerity.)*

(7) Whenever practical, give oral instructions or messages directly to the individual involved. Avoid transmitting the message through a middleman. He may not be as interested in sound, clear understanding or transmission of the message. *(CAUTION: When you must use a middleman, first, ensure the word he is to transmit is understood by him and, second, involve him in the responsibility for the results.)*

(8) Encourage questions and answer them fully. There really are no stupid questions. Sometimes, a person may test you by presenting a hypothetical situation, but this is seldom the case. *(CAUTION: If the other person has a question, it is most likely to be legitimate. Answer him seriously and fully to improve your communicative effectiveness.)*

(9) Ask questions as you communicate to establish commonality of knowledge. *(CAUTION: Do not ask questions in a way to create ill-feelings, defensiveness, and other negative emotions. Use your questions to ensure understanding of intent and constraints.)*

(10) Avoid the defeating dynamics of disagreement. Misunderstanding may be profitable, but disagreement is not. Disagreement can create overtones of violence causing defensive behavior which offers impossible barriers to understanding. Identify and handle a misunderstanding as early as possible in an effort to avoid degeneration into disagreement. *(CAUTION: To the maximum extent possible, avoid the red-faced, shouting confrontation of rabid disagreement.)*

(11) Although written communication has a large and important role in organizational functioning, you are much more likely to communicate with real understanding in two-way oral communication. Try to use the oral mode every time it is feasible and practical. *(CAUTION: Resort to paper when necessary to meet requirements, or when time or personal availability does not permit oral communication.)*

(12) Do not always assume your message is at fault when you sense a misunderstanding. It may be, but your timing and your selection of means to communicate may be erroneous. Further, it may be that your evaluation of feedback (which causes you to sense misunderstanding) is incorrect; and you are creating a problem where one does not exist. *(CAUTION: Try to consider a wide range of probable conditions before you jump to conclusions. Do not create a non-problem problem.)*

In summary, human cooperation is a function of understanding. Understanding is a function of effective communication. Effective communication demands feedback with both parties involved in a dynamic two-way effort. It is the role of the military leader to initiate and sustain this process. It is the leader's responsibility to create the climate in which effective communication becomes a common goal.

Fading Technologies: New Logistics Strategies

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Introduction

The problem usually begins with a letter from an electronic parts manufacturer to the Directorate of Contracting and Production, Defense Electronics Supply Center (DESC), which states that the manufacturer is discontinuing a particular electronic item, or perhaps even an entire product line. A DMSMS case has been born.

DMSMS

DMSMS is an acronym for Diminishing Manufacturing Sources Material Shortages. It also spells trouble—for DESC, which must buy and manage common electronic spare parts; for the Military Services, which own the equipment and systems in which the parts are used; and for the original equipment manufacturer (OEM), which must continue production of the equipment and systems. Others affected are soldiers, sailors, airmen, and marines whose lives depend upon the hardware into which those soon-to-be-discontinued electronic items must be fitted.

The DMSMS problem is universal in the world of military logistics (Figure 1), but it is especially serious in the electronics industry where technology changes so rapidly. As new technologies are born, old ones fade, become unprofitable, and are eliminated. Unfortunately, those now defunct items are still needed to support many military systems and may continue to be needed for as long as 30 years!

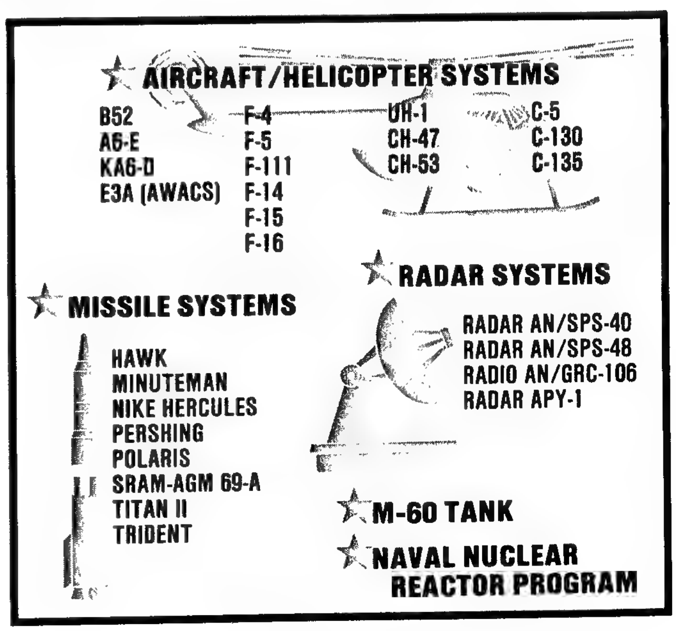

Figure 1.

The severity of the DMSMS problem has increased dramatically in recent years. The number of new DMSMS cases experienced by DESC has increased from 47 in FY79 (cost - $9.1 million) to 104 in FY81 (cost - over $40 million) (Figure 2). For FY82, DESC was budgeted $52 million for an anticipated 120 new DMSMS cases, 63 of which have materialized during the first half of the fiscal year. Each case can include anywhere from one item to an entire product line. One recent case consisted of 980 different stock numbers. Altogether, some 3,000 items managed by DESC fall into the DMSMS category and 20 of the 27 stock classes contain DMSMS cases.

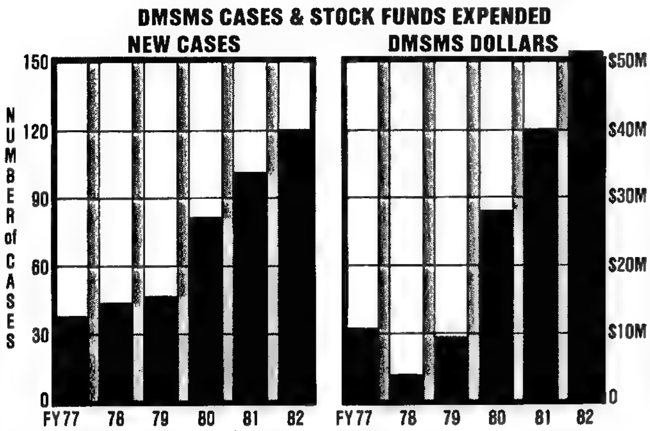

Figure 2.

The nature of the DMSMS cases also has changed in recent years (Figure 3). Not long ago tubes made up the greatest percentage of such cases; now it is integrated circuits. In FY81 tubes accounted for only about 13% of DMSMS cases, whereas integrated circuits comprised more than 40%. Other significant Federal Stock Classes were semiconductors at about 17% and switches at just over 10%. The 40% figure for integrated circuits was up from only 10% in FY78 and 20% in FY79. So it is not just old systems such as the B-52 bomber which are affected by DMSMS, but also newer ones like the F-16 fighter. In fact, some systems contain obsolete parts even before they roll off the production line.

In 1976, due to the seriousness of the DMSMS problem, DESC created a Central Control Staff to manage day-to-day DMSMS cases. This committee requires the strong support and cooperation of the electronic parts manufacturers. Many of these manufacturers have continued outdated and marginally profitable product lines because of a sense of patriotism and social responsibility. For others the profit and loss consideration has led to the decision to discontinue such items.

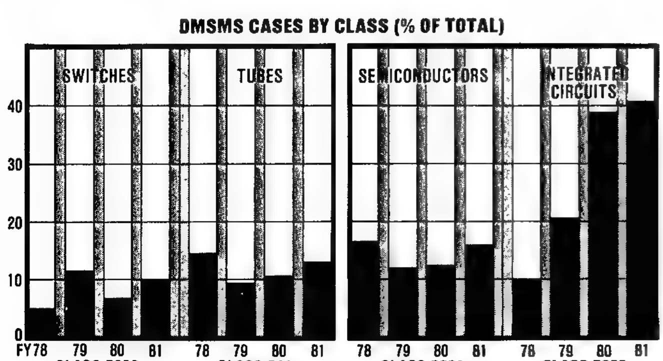

Figure 3.

DESC normally can choose from several alternatives in responding to a DMSMS case, but all require ample notification from the manufacturer who is discontinuing production (Figure 4). At least six months' notice is needed for DESC to ensure that the flow of that particular supply part to its customers is not interrupted. While most manufacturers are cooperative, some are not. In one case DESC received only two weeks' notice of a discontinuation.

SUPPLY SUPPORT ALTERNATIVES	PERCENT (AS OF OCT 81)
• ALTERNATE SOURCE	25
• ALTERNATE (SUBSTITUTE) ITEM	8
• MODIFICATION/REDESIGN	1
• LEVEL LOADING	1
• LIFE-OF-TYPE (LOT) BUY	19
• PRODUCTION CONTINUED	19
• OTHER	27

Figure 4.

Upon notification of discontinuation, DESC usually conducts a technical review of the item to determine if another item can be substituted or if other sources can be found which can produce it. An attempt also is made to persuade the manufacturer to continue production. These initial measures have been fruitful: production has continued in 19% of the cases, an alternative source discovered in 25%, and an alternate item substituted in 8% of the cases.

At other times less desirable actions must be taken. A procedure called "level loading" can be used to resolve some cases. DESC guarantees to buy a specified quantity or dollar amount of an item in the course of a year, with the possibility of extending the arrangement year by year. "Level loading" is used in only about 1% of the DMSMS cases, primarily to purchase tubes. Required production runs for integrated circuits and semiconductors generally are too high for level loading—DESC may want to buy several thousand units while the manufacturer may want to sell several hundred thousand.

Sometimes the Military Services can redesign discontinued parts out of the system. This procedure is used only in 1% of the DMSMS cases because redesign often is too expensive and time-consuming to be practical. For example, the cost to redesign 15 discontinued items out of the APY-1 Radar System was estimated to be in the $50-$100 million range, whereas the lifetime requirement for those items was satisfied with a buy-out at a cost of $4 million.

In 19% of DMSMS cases, DESC makes such lifetime buy-outs of items before production grinds to a halt. In other words, DESC attempts to buy enough of the discontinued items to support the requirements of all the equipment and systems in which the items are used for as long as they are used.

Making a lifetime buy poses problems, one of which is accurately determining just how many items will be needed. When DESC determines a lifetime buy is necessary, it seeks such information as: (1) what equipment the item is used in and in what quantity; (2) how long it will be in the field; (3) whether it will increase or decrease in use; and (4) whether production of the equipment will continue and, if so, in what quantities and for how long. DESC then notifies the Military Services to ensure that all requirements are included.

DESC also takes great pains to identify all original equipment manufacturers who require the items to produce equipment and systems, and also those doing contracted repair work for the Military Services. This demand is not normally visible to DESC, so it is important that they have close contact and dialogue with the parts manufacturers in order to discover which equipment manufacturers and repairers use the discontinued items. The OEMs have the option of making a lifetime buy themselves, but are unlikely to do so without a contract in hand for production. The Military Services can give DESC the estimated OEM requirements, in which case DESC will include that number in its lifetime buy. Then the OEMs can requisition the items directly from DESC, when needed, if they have authority to do so, or the Services can acquire the items from DESC and provide them to the OEMs as government-furnished materiel.

Another consideration in a buy-out is Foreign Military Sales (FMS) customers. DESC notifies the International Logistics Office for each Military Service when a buy-out is required and they in turn contact affected FMS customers. DESC can buy to support the needs of FMS customers, but only if they provide the funds in advance of the purchase with a requisition indicating their lifetime needs.

Sometimes data is lacking for a particular item. In this case, DESC reviews item demand for the previous two years for all customers and makes a buy to fulfill estimated future needs for a 10-year period.

Once the items have been purchased, DESC faces the problems of storage so that they will be available and usable in 10, 20, or even 30 years. To meet this requirement, specially designed, long-term storage facilities have been established at Defense Logistics Agency depots in Odgen, Utah, and Richmond, Virginia. There integrated circuits are stored in the static free environment of old Navy gunpowder canisters filled with dry nitrogen, where they are subject to periodic inspections. At present, integrated circuits are the only DMSMS items in long-term storage.

Those DMSMS cases not resolved by buy-outs or other previously mentioned alternatives may be resolved by substituting commercial parts for military specification parts or by the manufacturer being granted a waiver allowing him to forego some of the testing normally required in military specification electronic items. Such actions can only be taken when authorized by the Military Services.

Conclusion

DMSMS is a serious problem, but ironically the current recessionary economy has tended to slow the growth of DMSMS cases. With less commercial demand for electronic items, the lower volume military business (for example, military requirements make up only 5%-7% of the semiconductor market) has become more important to parts manufacturers. But as the economy improves, DMSMS cases will probably increase.

What is the answer to the DMSMS problem? It is a problem that can be solved only by the active cooperation of the electronics industry and its military customers. When one stops to think that the unavailability of a single electronic part can ground a $23 million aircraft, the importance of finding an answer to the DMS dilemma becomes obvious.

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"But the process by which strategy, defense budgets, and weapons policies are conceived and implemented cannot be more accurately described than political in the most fundamental sense of the term."

Michael H. Armacost in *The Politics of Weapons Innovation: The Thor-Jupiter Controversy*

CURRENT RESEARCH

Air Force Human Resources Laboratory FY 83-84 Logistics R&D Program

The Air Force Human Resources Laboratory, with Headquarters at Brooks AFB, Texas, is the principal organization charged with planning and executing the USAF exploratory and advanced development programs in the broad areas of: (1) Manpower and Force Management; (2) Air Combat Tactics and Training; (3) Weapon Systems Logistics, Maintenance and Technical Training. The latter thrust area is functionally managed by the Logistics and Technical Training Division of AFHRL located at Wright-Patterson AFB, Ohio, with a major Branch located at Lowry AFB, Colorado. All of the Laboratory's efforts to improve Air Force logistics are managed within this thrust area. Some efforts are undertaken in response to technology needs identified by the Laboratory, but the majority of the work is in response to formally stated requirements from various Commands and staff agencies within the Air Force. Projects vary from basic research aimed at producing new fundamental knowledge to applied projects which are intended to demonstrate the technical feasibility and military effectiveness of a proposed concept or technique.

Following are some logistics R&D projects being managed by the Logistics and Technical Training Division which will be active during FY83 and FY84 (Contact: Colonel Donald C. Tetmeyer, AUTOVON 785-6797/3713, (513) 255-6797/3713).

LOGISTICS ANALYSES FOR THE INTEGRATED COMMUNICATIONS, NAVIGATION, IDENTIFICATION AVIONIC (ICNIA) SYSTEM

OBJECTIVE: To identify tools and techniques to incorporate logistics engineering parameters into system design during the conceptual phase. These analysis techniques will be demonstrated by applying them to the front-end analysis portion of the ICNIA conceptual phase. Among the unique problems being addressed is the development of analytic reliability analysis techniques for graceful degradation.

APPROACH: This effort will include three major tasks applied to two conceptual ICNIA system architectures that were developed by the Air Force Avionics Laboratory. The three major tasks involve developing front-end analysis techniques in the areas of logistics support, reliability, and survivability, and applying them to the two ICNIA systems' architectures.

(James McManus, LRLR, AUTOVON 785-3611, 513-255-3611)

MAINTENANCE AND LOGISTICS MODELS FOR COMPUTER AIDED DESIGN (MLCAD)

OBJECTIVE: To produce tested analytical models, data bases, and procedures for including maintenance and logistics factors within the computer aided design (CAD) process. A biomechanical model of the maintenance technician will be developed which will enable designers to evaluate maintainability during initial design.

APPROACH: Maintenance and logistics (M&L) factors relevant to CAD will be identified and associated with the various design phases of weapon system acquisition. Several representative factors will be selected for integration with CAD. Computer-based analytical models will be developed for selected factors. An existing biomechanical model will be selected and adapted to represent a maintenance technician. Data bases will be developed to support use of the models in a design environment.

(William B. Askren, LRLA, AUTOVON 785-3771, 513-255-3771)

UNIFIED DATA BASE FOR WEAPON SYSTEM DESIGN

OBJECTIVE: To develop a limited prototype of a computerized Unified Data Base (UDB) of logistics data and the associated Users' Guide and Maintenance/Update Handbook to support the weapon system design process. The UDB will be for the use of engineers, logisticians, and managers within AFTEC, AFALD, AFLC, and the Aerospace industry. The UDB fully automates current MIL-STD-1388 requirements and also provides significant experience data on comparable equipment in a consistent system readily accessible to designers and logistics planners.

APPROACH: During Phase I, specifications will be developed for a UDB which will address the logistics data requirements of various USAF organizations. Maintenance action estimating relationships developed in previous exploratory development work will be investigated. During Phase II, the UDB will be programmed for computer availability. Operationally generated AFTEC data systems and technologies will be addressed via the UDB. A Users' Guide and Maintenance/Update Handbook will be prepared. During Phase III, the UDB and associated handbooks will be given a limited test and demonstration on the Air Force HH-60 helicopter which is under development.

(Robert N. Deem, LRLA, AUTOVON 785-3771, 513-255-3771)

DEMONSTRATION OF A UNIFIED DATA BASE FOR LOGISTICS INFORMATION

OBJECTIVE: The development, demonstration, and test of a computerized unified data base (UDB) of logistics information, and the associated Users' Guide and Maintenance/Update Handbook to support the weapon system design process.

APPROACH: UDB technology developed under an exploratory development program will be demonstrated and tested on a major weapon system program in this advanced development effort. Interfaces with computer aided design, weapon system testing, and product performance feedback will be developed and evaluated. Audit trails of particular data values will be reported and documented via the software developed. This will be done in order to identify and adjust any large fluctuations.

(Robert N. Deem, LRLA, AUTOVON 785-3771, 513-255-3771)

ANALYSIS TO IMPROVE THE MAINTENANCE ENVIRONMENT

OBJECTIVE: To develop a comprehensive, integrated, long-range research and technology application program designed to increase the overall effectiveness of Air Force maintenance organizations.

APPROACH: Conduct approximately 1800 open-ended interviews with maintenance technicians, supervisors, managers, and planners representing the areas of active duty aircraft and missile maintenance.

(Richard E. Weimer, LRLC, AUTOVON 785-2606, 513-255-2606)

IMPROVING MAINTENANCE DIAGNOSTICS

OBJECTIVE: Correct diagnostic deficiencies on selected items of fielded avionics equipment and develop design criteria to reduce diagnostic problems on future weapon systems.

APPROACH: Phase I will identify at least 10 LRUs experiencing high retest OK and/or cannot duplicate rates. Phase II will examine and analyze 3 or 4 LRU categories from the list generated in Phase I. These LRUs will be studied with efficient experimental designs which permit the identification and measurement of sources of diagnostic errors. Potential corrective measures will be identified. Phase III will implement the corrective measures identified in Phase II.

(Alan E. Herner, LRLA, AUTOVON 785-3771, 513-255-3771)

AUTOMATED MAINTENANCE PERFORMANCE AIDS

OBJECTIVE: To develop and evaluate prototype automated aids for presentation of technical information for use by maintenance technicians through automation to allow selective data display tailored to individual skill and experience, as well as to provide rapid and reliable update.

APPROACH: A series of small design studies will be accomplished to establish system requirements for factors such as display resolution, data presentation formats, and the man/machine interface. Emphasis will be placed on developing systems which are easy to use, which provide all the information that the technician needs, and which increase the technician's capability to perform maintenance. The system will be tested and evaluated by formating and displaying technical data for the B-1B aircraft.

(David R. Gunning, LRLC, AUTOVON 785-2606, 513-255-2606)

3-D GRAPHICS BATTLE DAMAGE ASSESSMENT AID

OBJECTIVE: To develop and evaluate a prototype computer based graphics and information system for use by aircraft battle damage assessors, to help assessors make quick battle damage evaluations, to assess impact on aircraft integrity, and to identify repairs required to return the aircraft to operational status.

APPROACH: The information needs of aircraft battle damage assessors will be identified. Hardware and software required to store, retrieve, and rapidly present the required data then will be developed. The system will be a small, rugged, portable device which is capable of storing and presenting a variety of structural and systems information.

(Warren T. Payne, LRLC, AUTOVON 785-3771, 513-255-3771)

COMBAT MAINTENANCE CAPABILITY

OBJECTIVE: Develop and test methods by which the Air Force can measure, quantify, and improve its combat maintenance capability. Such methods can be used by Air Force decision makers in determining policies, planning resources for combat, preparing units for combat, conducting operational exercises, enhancing combat logistics and maintenance effectiveness, and influencing the design of more supportable future weapon systems.

APPROACH: An in-depth comparison will be made of peacetime and combat maintenance. Base level maintenance and associated logistic capabilities necessary for successful combat sortie generation will be determined. Differences in how equipment fails under combat stress as opposed to peacetime usage will be identified and quantified.
(Gene L. Stevens, LRLC, AUTOVON 785-5910, 513-255-5910)

DEMONSTRATION OF COMBAT MAINTENANCE CAPABILITY TECHNOLOGY
OBJECTIVE: Demonstrate and validate methods to more accurately determine logistics requirements for maintenance units during wartime operations, improve performance of maintenance units during wartime operations, and enable wing commanders and staff assistants to assess and measure the ability of maintenance units to perform their wartime tasks.
APPROACH: Technology produced under exploratory development programs will be demonstrated and tested under this advanced development effort. Phase I will test and refine methodologies and procedures developed in previous efforts to determine their capability to specify spares, manpower, skill levels, etc., required for successful performance of wartime maintenance and logistics units. Phase II will field test and evaluate models, methods, and procedures developed to predict logistics and maintenance combat requirements. Phase III will test, evaluate, and document changes in procedures to enhance combat capabilities and model effectiveness in predicting and measuring a unit's combat capability.
(Gene L. Stevens, LRLC, AUTOVON 785-5910, 513-255-5910)

DEFINITION OF AN INTEGRATED TRAINING SYSTEM FOR OJT
OBJECTIVE: To define an improved system of management and evaluation for Air Force on-the-job-training (OJT). The end product will be a specification of system functions and hardware recommendations to include clear identification of the common and the unique tasks for each AFSC by position and to provide systematized procedures for training development and performance certification.
APPROACH: This effort is the first step in a larger advanced development program designed to demonstrate a state-of-the-art training system for Air Force OJT. Phase I is devoted to answering basic questions about the characteristics desired in a new OJT system. The questions include:
(1) What kind of functions are desired in the management and evaluation of training?
(2) What kind of organizational structures are appropriate and feasible?
(3) How can quality control of OJT be maintained and what data bases are needed?
Phase II involves performing trade-off studies as needed, and Phase III encompasses writing the specification as well as selecting a site and making plans for the system demonstration and test.
(James R. Burkett, LRTT, AUTOVON 926-2784, 303-370-2784)

INTEGRATED TRAINING SYSTEM FOR OJT
OBJECTIVE: To develop and demonstrate an integrated training system (ITS) for Air Force OJT. Major elements of this system are new evaluation and management procedures which can be implemented in an integrated manner at all levels of the Air Force OJT program from first-line supervisors to the Air Staff Program Manager.
APPROACH: A full-scale demonstration is planned for a single Air Force base, which is chosen as representative of the Air Force mission, with data links to MAJCOM and Air Staff agencies. Four subsystems will be developed to implement and support the demonstration: evaluation, management, computer support, and personnel. This contractor will monitor component and subsystem integration and will recommend potential immediate benefit areas for transition.
(James R. Burkett, LRTT, AUTOVON 926-2784, 303-370-2784)

COMPUTER GRAPHICS FOR MAINTENANCE TRAINING
OBJECTIVE: To develop a graphic level simulation of various operator and maintenance tasks associated with the 6883 Avionics Test Station that will be used to acquire information concerning its cost-effective uses when compared to higher fidelity simulations.
APPROACH: A four phase approach is being followed. Phase I consists of data collection and analysis and development of a functional specification. In Phase II, a system will be fabricated, a pilot group will be tested, and on-site testing will be conducted. Phase III will consist of delivery, acceptance testing, and test and evaluation. Phase IV consists of the submission of the final report, extended warranty, and low cost system specification.
(Edgar A. Smith, LRTI, AUTOVON 926-3221, 303-370-3221)

HANDBOOK AND SPECIFICATIONS FOR MAINTENANCE TRAINING EQUIPMENT
OBJECTIVE: To develop a set of introductory handbooks for instructional system development teams and training system acquisition managers involved in requirement development, design, and procurement of maintenance training equipment.
APPROACH: The approach used involves the collection, analysis, and documentation of information on the design, fabrication, and life cycle logistics support of maintenance training devices.
(Edgar A. Smith, LRTI, AUTOVON 926-3221, 303-370-3221)

GENERAL PURPOSE TROUBLESHOOTING TRAINER
OBJECTIVE: To develop, install, and evaluate a general purpose troubleshooting trainer, which will be suitable for a wide variety of troubleshooting training applications.
APPROACH: The following major tasks are being performed: functional analysis; malfunction analysis; develop, program, and deliver trainer; and conduct formative and summational evaluation. A functional and malfunction analysis is being performed to identify malfunctions for training and to provide a framework for troubleshooting.
(Edgar A. Smith, LRTI, AUTOVON 926-3221, 303-370-3221)

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Project Warrior

Project Warrior is a concept fomulated to create an environment where our people can learn from the warfighting lessons of the past and use that knowledge to better prepare for the future.

Logistics Warrior

Logistics Warrior is the contribution of your journal to help create that environment. Your suggestions are solicited.

LOGISTICS WARRIORS: Scientific Study of War

"If the study of war in the past has so often proved fallible as a guide to the course and conduct of the next war, it implies not that war is unsuited to scientific study but that the study has not been scientific enough in spirit and method.

It seems hardly possible that the authoritative schools of military thought could have misunderstood as completely as they did the evolution that was so consistently revealed throughout the wars of the nineteenth and early twentieth centuries. A review of the record of error suggests that the only possible explanation is that their study of war was subjective, not objective.

But even if we can reduce the errors of the past in the writing and teaching of military history by soldiers, the fundamental difficulty remains. Faith matters so much to a soldier, in the stress of war, that military training inculcates a habit of unquestioning obedience which in turn fosters an unquestioning acceptance of the prevailing doctrine. While fighting is a most practical test of theory, it is a small part of soldiering; and there is far more in soldiering that tends to make men the slaves of theory.

Moreover, the soldier must have faith in his power to defeat the enemy; hence to question, even on material grounds, the possibility of successful attack is a risk to faith. Doubt is unnerving save to philosophic minds, and armies are not composed of philosophers, either at the top or at the bottom. In no activity is optimism so necessary to success, for it deals so largely with the unknown—even unto death. The margin that separates optimism from blind folly is narrow. Thus there is no cause for surprise that soldiers have so often overstepped it and become the victims of their faith.

The soldier could hardly face the test defined in the motto of the famous Lung Ming Academy, a motto that headed each page of the books used there: 'The student must first learn to approach the subject in a spirit of doubt.' The point had been still more clearly expressed in the eleventh-century teaching of Chang-Tsai: 'If you can doubt at points where other people feel no impulse to doubt, then you are making progress.' "

From: *Why Don't We Learn From History?* by B. H. Liddell Hart.

LOGISTICS WARRIORS: Apache Revenge

"Nana was seventy years of age, a Gileno Apache of the Warm Springs band. He was participating in raids on Mexican settlements and ranches when Victorio was a child. For several decades he had been a leader of marauding groups, but in middle life he had suffered from prolonged periods of sickness. He had sustained several serious wounds, one of which had given him a permanent limp. His limbs had become afflicted with rheumatism, and he was often in great pain. Younger men had superseded him as a chief.

Yet Nana seemed to be indestructible. There were times when he had difficulty getting on a horse, but once mounted he could endure as well as young men all the hardships and ordeals of a long flight from pursuers. On more than one occasion when troops were pressing Victorio's band he was known to have ridden three horses to death, traveling with others as much as seventy or eighty miles without stopping. Despite his advanced years and poor health, he had not mellowed. He has lost none of the courage, none of the spirit, none of the shrewdness and cunning which had for so long made him a dangerous and capable fighter. And, perhaps most important of all, the fire of his hatred for the invaders of his homeland still burned in him with undiminished fury.

It was the aged, bent, crippled, grizzled Nana who rallied the remnants of Victorio's shattered renegades. He inspired them with his refusal to admit defeat, with his unqualified zeal and determination. He took command and he set out with them on a series of swift raids by which they obtained new supplies of weapons and ammunition, food and equipment, and fresh horses.

Before he raided north of the border there was one thing Nana wanted to do, and that was to avenge the death of his great friend and commander, Victorio. For sheer daring, if not madness, his plan had few equals in the annals of Apache warfare.

Nana and his warriors—there could not have been more than forty of them, and probably fewer than that—lay in ambush near Carrizal, where the main road between Chihuahua City and El Paso passed through a defile between bluffs. His scouts had reported that General Terrazas, the conqueror of Victorio, was to pass that way, and the intelligence proved to be accurate.

Preceded by a company of cavalry, and surrounded by an escort of ten aides, General Terrazas appeared. In the first volley, nine soldiers died and as many were wounded. The Apache concentrated their fire the next moment on the general's escort. Nine of them were killed, and the general was saved only by the quick action of troopers who rushed to protect him. The general and his rattled men fled along the road at a wild gallop.

Nana and his warriors swept down and finished off the fallen wounded. One of them was a Mexican sergeant who was adorned with trinkets taken from Victorio's body. He was quickly cut into small pieces.

Nana and his band, with more horses and Mexican guns and cartridges, vanished toward the mountains."

From: *Apache Chronicle* by John Upton Terrell.

LOGISTICS WARRIORS: Ranch Hand, 1966

"Hostile fire was present over most targets, but Ranch Hand's increasing level of operations made fighter cover difficult to obtain during part of the period from September through November 1966. Lack of fighter escort caused cancellation of some missions, especially in III and IV Corps. In August, Ranch Hand received three new spray planes, and four more were added in September bringing the total number of UC-123s available to fourteen. Ranch Hand crews, eager to accomplish as much as possible with the new aircraft, occasionally tried to do too much. Clear weather in the area just south of the Demilitarized Zone (DMZ) in September 1966 allowed Ranch Hand to fly as many as four sorties per aircraft per day. Predictably, the herbicide supply ran low and the planes fell behind on their maintenance schedules. These circumstances forced the crews to stretch out their operations so that maintenance and supply could catch up."

From: *Operation Ranch Hand* by William A. Buckingham, Jr.

LOGISTICS WARRIORS: Marshall and Roosevelt, 1938

"One of the most important of the meetings on military policy Marshall attended as deputy chief of staff occurred in the White House on the afternoon of November 14, one month after he took over the post. The Western Hemisphere was vulnerable to attack, President Roosevelt asserted, and this situation demanded the immediate creation of a huge air force so that the United States would not need to have a huge army. It was politically impossible to send a large army abroad. A powerful air force was essential to back up the administration's foreign policy. The United States needed ten thousand airplanes and the capacity to produce twenty thousand more per year.

Marshall believed that the president's new program was unbalanced and underfunded. Not only did it favor the Air Corps over the army as a whole, it concentrated too much on machinery at the expense of other Air Corps needs. The White House meeting, he recalled, was 'quite an assembly of men and a great many of the New Deal protagonists; it had to do with these appropriations we were trying to get of a military way. There was a great difference of opinion as to what it should be. The president, of course, was all for the increase in the air, but he wasn't much for getting the men to man the airships nor for the munitions and things that they required. He was principally thinking at that time of getting airships for England and France.'

Marshall remembered sitting 'on a lounge way off to the side' in the White House meeting room. Roosevelt finished his presentation and began asking the other participants' opinions. 'Most of them agreed with him entirely, had very little to say, and were very soothing in their comments. He, of course, did the major portion of the talking. He finally came around to me, . . . and I remember he called me "George." I don't think he ever did it again. That rather irritated me, because I didn't know him on that basis. Of course, the president can call you pretty much what he wants to, but nevertheless I wasn't very enthusiastic over such a misrepresentation of our intimacy. So he turned to me at the end of this general outlining . . . and said, "Don't you think so, George?" And I replied, "Mr. President, I am sorry, but I don't agree with that at all." I know that ended the conference, and the president gave me a very startled look.

'When I went out, they all bade me goodbye and said my tour in Washington was over. But I want to say in compliment to the president that that didn't antagonize him at all. Maybe he thought I would tell him the truth so far as I personally was concerned—which I certainly tried to do in all of our later conversations. He thought I was too intent on things, of course, and he was having a very hard time raising the public backing for the money, and there was a debt limitation during these early periods. But my job was to see that the country was armed, if it was possible to do so, which meant large appropriations.' "

From: *The Papers of George Catlett Marshall* (Vol. 1) edited by Larry I. Bland.

LOGISTICS WARRIORS: Valley Forge, 1778

"One incident in particular epitomized the senselessness of it all. General Anthony Wayne, famous for his daring leadership in battle, tried to make arrangements to get 500 coats for the ill-clad men under his command. The Clothier General, James Mease, a Congressional appointee, insisted that only authorized civilian tailors could do the work. While Wayne's troops continued to suffer, Mease took a leave of absence, and there was no one who could process the order. When he returned to duty, the Clothier General refused to issue the uniforms because only yellow buttons were available and Pennsylvania's regimental design specified white buttons. Finally, an apoplectic Wayne had the specifications changed, and Mease released the coats. How many of Wayne's soldiers died from exposure while this farce was playing itself out has never been determined."

From: *A Respectable Army: The Military Origins of the Republic, 1763-1789* by James Kirby Martin and Mark Edward Lender.

LOGISTICS WARRIORS: Japan-USSR in Mongolia -1939

"While the overwhelming Soviet qualitative and quantitative materiel superiority ultimately defeated the Japanese at Nomonhan, the defeat cannot be ascribed to materiel deficiencies alone. A tactical doctrine designed for infantrymen that stressed offensive action to achieve a quick victory was pitted against a doctrine which emphasized combined arms and protracted warfare. The Japanese decision to fight a war of attrition against the superior Soviet Red Army was, in retrospect, a mistake. It should be remembered that the Kwantung Army based its decision on its perception of how the Soviets would fight. In other words, the dynamism between Japanese values and assumed enemy capabilities produced a Japanese tactical doctrine that was neutralized when the Soviets did not fight according to Japanese expectations. Only the decision of a battle exposes what later generations regard as self-evident truths.

First Lieutenant Sadakaji, with his sword attacking Soviet tanks, personified the dilemma of doctrine and force structure which impaled the Japanese. A paucity of resources and money dictated a light infantry force structure. A tactical doctrine to complement this force structure emerged after decades of painstaking analysis and heated arguments. To alter drastically IJA tactical doctrine was, in effect, to pull the props from under Japanese spirit—the intangibles of battle—to deny the martial values themselves. Perhaps it could have been done, and the end result would have been an army with a glittering array of weaponry, but no soul."

From: *Leavenworth Papers* (No. 2) by Edward J. Drea.

LOGISTICS WARRIORS: Enhancing NATO

"Prepared fortifications, barriers, and obstacles offer a third alternative means for significantly enhancing NATO conventional defense capabilities. The concept is nearly as old as warfare itself. Successful defenders have always taken advantage of terrain and man-made enhancements thereto, to increase defensive combat power. Fortifications conceal and protect the defender, his supplies, and communications from incoming fire and therefore enable him to place more accurate fire on the attacker. Barriers and obstacles slow the attacker thus increasing his exposure to defender's fire, and hence his casualties. Studies show that slowing an attacker to a third of his original speed will increase his casualties by 60 percent. Barriers, such as mines, may also inflict casualties. Furthermore, barriers disrupt time schedules, disorganize units, and cause the attacker to mass in kill zones rather than on planned objectives. This thereby nullifies his advantages of speed, initiative, and shock action. In effect, through judicious terrain preparation, the defender can seize the initiative from the attacker.

Current NATO defense plans obviously incorporate prepared defensive positions into strategy, as well as minefields, craters, bridge demolition, and the like. Since none of these are in place, however, the wartime extent of such preparations is entirely a function of warning time, political decision time, quantity and location of prestocked barrier materials, and the amount of engineer support available. In all but a very long warning scenario coupled with rapid political decisions, no field commander will get adequate time or support for full execution of his defensive-position preparations or barrier plan. Fifteen days' time is considered necessary for the hasty defense (which increases the defender's combat power by a factor of roughly 1.25), yet many threat assessments postulate that M+15 is precisely the time of greatest Pact advantage, relative to NATO. If defensive forces are already dangerously inferior relative to the opponent, it seems the height of folly to gamble on long warning, particularly when many barriers (excluding mines), obstacles, and even defensive works can be prepared in peacetime without undue interference with civil pursuits."

From: National Security Affairs Issue Paper No. 81-3 by Lt Col Waldo D. Freeman, Jr.

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"... Logistics is the bridge between the economy of the nation and the tactical operations of its combat forces. Obviously, then, the logistics system must be in harmony both with the economic system of the nation and with the tactical concepts and environment of the combat forces."

Military Concepts and Philosophy
by Adm Henry E. Eccles, USN (Ret)

Air Force Journal of Logistics
Air Force Logistics Management Center
Gunter AFS, Alabama 36114